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PNNL--11272

TFA
TANKS
FOCUS AREA

Multiyear Program Plan FY97-FY99

August 1996

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Tanks Focus Area Multiyear Program Plan FY97-FY99

August 1996

Prepared for
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Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

The U.S. Department of Energy (DOE) continues to face a major tank remediation problem with approximately 332 tanks storing over 378,000 m^3 of high-level waste (HLW) and transuranic (TRU) waste across the DOE complex. Most of the tanks have significantly exceeded their life spans. Approximately 90 tanks across the DOE complex 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 National 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) began operation in October 1994. The focus area 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. The TFA is responsible for technology development to support DOE's four major tank sites: Hanford Site (Washington), INEL (Idaho), Oak Ridge Reservation (ORR) (Tennessee), and Savannah River Site (SRS) (South Carolina). 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 Science and Technology (EM-50). In the future, the TFA will integrate activities across and beyond the DOE complex.

During its first year, the TFA was committed to deliver, a technology program that was

- applicable - addressed users' needs and was implemented within budget, schedule, and regulatory constraints

- integrated - leveraged relevant activities across EM-30, EM-40, and EM-50, and across and beyond the DOE complex

- acceptable - had broad involvement of key stakeholders and incorporated expertise from outside the laboratory system (e.g., from industry and universities)

- accountable - performed within budget and on schedule and produced a clear benefit.

At the same time, the technologies provided by this program were to

- reduce the technical risks that jeopardized baseline tank remediation performance requirements

- reduce the programmatic risks that 1) jeopardize the sites' ability to comply with regulatory or stakeholder drivers not formalized in baseline plans or 2) limit the sites' 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 responded to this challenge by pursuing a phased management and technical strategy. The program focused initially on technologies that could be rapidly deployed or meet near-term needs at multiple sites under multiple possible baselines (e.g., privatization). In the last year, the TFA made significant progress toward completing DOE investments in technologies ready to be demonstrated and successfully deployed. The initiation of demonstration and transition of these technologies to users began to reduce the level of the TFA's "mortgage," permitting a desired shift of focus on less mature technical initiatives offering potentially greater payoffs.

The FY96-98 multiyear program plan (MYPP) (TFA 1995) documented a recommended 3-year technical program and described the path forward for its implementation. The FY97-99 plan recommends retention of that path forward but includes an intentional shift to a program more based on problems and site needs.

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

- needs assessment - The TFA asked the Site Technology Coordination Groups (STCGs) at each of the four tank waste sites to identify and update their technology needs for tank waste remediation. The needs were cataloged within the needs breakdown structure used last year. Recognizing the benefit of a more compact, problem- and system-oriented structure, the TFA developed a

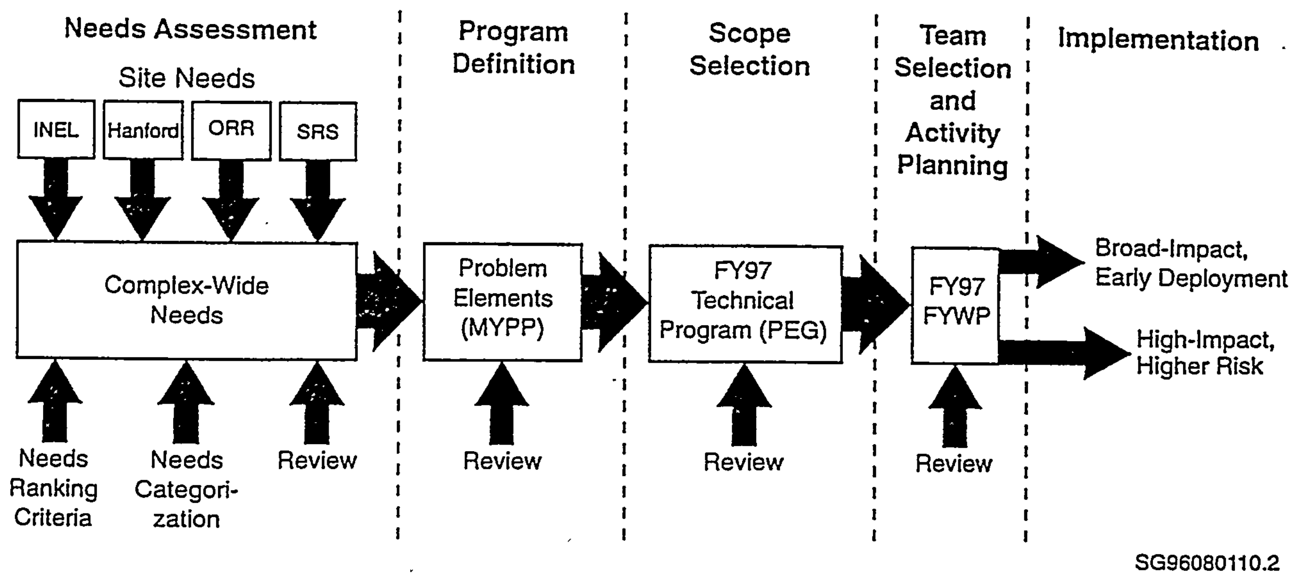

Figure ES.1. TFA Program Development

problem element structure to replace the needs breakdown structure. Each need was put within the problem element structure, based on priorities provided by each site, as well as cost reduction potential, confidence that satisfaction of the need would increase the sites' ability to remediate tanks, and benefit on a DOE complex-wide basis. Needs fulfilling these criteria were labeled "high impact" and formed the basis for program definition. The process and results are documented in the *TFA FY 1996 Site Needs Assessment* report (TFA 1996).

- program definition - Focusing on the high-impact needs, the TFA assessed the similarities between needs and the sites' schedule requirements for matching technical responses. This assessment included those technical responses presently underway in FY96 that continue into the FY97-99 period. For the FY98 program, the TFA consolidated, where appropriate, site needs within the problem element structure. These groupings permitted development of initial problem definitions, general work scopes, and anticipated major milestone and schedule events. Using preliminary DOE budget guidance, the TFA developed the FY98 technical response, prioritizing each anticipated task.

- scope selection - The initial scope and schedule for each FY97 technical task were established during this same process last year. These were updated during the program execution guidance process during June-July 1996. These reviews included site representatives, STCGs, the TFA User Steering Group (USG), and the TFA Technical Review Group. For new tasks that start in FY98, the TFA will update the initial scopes throughout the year, culminating in the same process used for FY97 tasks.

- team selection and activity planning - The TFA team identified 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 FY97 work plan. Final plans for calls for proposals will be completed and executed in time to initiate work when funds are available after October 1, 1996.

Each of these steps has been or will be reviewed for programmatic and technical validity. To ensure programmatic viability and facilitate eventual deployment, the TFA is guided by a USG comprised of senior managers of the site tank remediation programs. The USG has participated in the review and validation the TFA needs assessment and the selection of high-impact needs. 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 last year's MYPP generally focused on solutions planned for deployment within site baselines in 1 to 3 years. These near-term solutions emphasized relatively mature technologies, many of which were developed by EM for several years but may not have received the national, focused attention that this program provided. The solutions were primarily aimed at reducing technical risk and offer enhancements to or fill gaps in current site baselines. Last year, five technologies were mentioned that offered early and relatively certain site benefits and were directly integrated with site programs and budgets. During the past year, progress has been made on these technologies. The progress is described in the following bullets.

- Advanced Hot-Cell Analytical Technology - These technologies were developed as a "rapid response" to Defense Nuclear Facilities Safety Board demands for more effective characterization of Hanford tanks. The technologies were deployed in 222-S Laboratory at Hanford and will provide immediate benefit by using laser ablation/mass spectrometry for HLW elemental analysis (required to characterize waste and design processing flowsheets), and near infrared scanning for moisture (a safety concern). In addition to providing an early win at Hanford for faster and cheaper characterization data, the technologies will reduce secondary waste generation and personnel exposure. The technologies have potential applications to other EM remediation problems (e.g., mixed waste).

- Deployment Systems - In April 1996, the Light-Duty Utility Arm (LDUA) was delivered to Hanford for testing. It provides 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. Training for LDUA team members from Hanford, INEL, and ORR has also been completed in FY96. The LDUA remains on schedule for demonstration and deployment for separate missions at Hanford and ORR during FY96 and FY97. Formal testing of the LDUA Data Acquisition System was completed, and the LDUA High Resolution Stereoscopic Video System was delivered. An unanticipated implementation of the deployment technology occurred when a scanner, developed in support of the LDUA

Nondestructive Examination End Effector, was used to investigate the condition of the cladding at INEL. The LDUA will provide a much improved capability to deliver tools to the right spot in a tank.

- Retrieval Process Development - At ORR, INEL, and Hanford, the confined sluicing process uses high pressure jets and low water volume to effectively mobilize hard-to-remove sludges from tanks. It can be extremely useful in tanks that leak or have complex internal hardware that make waste removal more challenging. In FY96, the Confined Sluicing End Effector (CSEE) was successfully developed and delivered for the removal of the heels in Tanks W3 and W4 as part of the ORR Gunite and Associated Tanks Treatability Study. During FY97, the deployment of the CSEE in a radioactive waste tank at ORR will be supported by the retrieval process development and enhancements activity of the TFA. This CSEE technology will also be evaluated under both vehicle and Modified LDUA deployment. In FY97, an extendible nozzle will be deployed in Tank 19 at SRS to mobilize a hard zeolite heel for further characterization. Another retrieval technology, Pulsair, removes waste by introducing large gas pulses at 690 to 2,070 kPa (100 to 300 lb/in^2). In FY97, the Pulsair technology will be prepared for deployment in a radioactive waste tank.

- Alkaline Cesium Removal - The FY96 cesium removal demonstration at ORR described in the FY96-98 MYPP was to provide critical data on the most cost-effective sorbents to use within different flowsheets. This supports key processing decisions related to selecting ion-exchange sorbents (at ORR), in-tank precipitation alternatives (at SRS), and baseline cesium removal processes (at Hanford). Thus far in FY96, the demonstration system was procured and installed at ORR. The plan is to operate the system to treat 83,279.06 L (22,000 gal) of Melton Valley Storage Tank supernate beginning in FY96 and continuing into FY97. Crystalline silicotitanate has been selected for the demonstration, and laboratory test columns on actual waste have been run to develop data needed for the demonstration.

- Waste Processing and Tank Closure Demonstration - The TFA has joined with SRS to conduct a waste retrieval and closure demonstration in two tanks at SRS over the period FY96-98. Low cost saltcake retrieval will be demonstrated by using the modified density gradient method in Tank 41. The objective is to develop cost and performance data for saltcake removal and clean out for in-tank precipitation processors. An extendible nozzle will be deployed in Tank 19 to mobilize the hard zeolite heel remaining from mixer pump retrieval. The mobilization will help further characterize the heel and help establish cleaning criteria and tank closure. The objective is to develop and implement closure criteria and strategies to close a HLW tank. Data from these tests will be major contributions to tank decision processes at the four DOE tank sites.

These tasks show the TFA's response to its technology development challenge. Yet, the knowledge acquired in the past year helped the TFA develop a more strategic approach to tanks technology development integration. An outcome was TFA's identification of four technical strategic goals:

- demonstrate, deploy, and provide performance data for four tank waste retrieval systems to meet EM's FY00 requirements

- provide tank waste treatment technologies that can efficiently pretreat and immobilize 80% of HLW

- demonstrate compact processing units for HLW treatment and immobilization as a cost-effective alternative to large-scale facilities

- provide subsystems necessary to support the closure of 16 radioactive waste tanks: Hanford (2), ORR (10), and SRS (4).

These strategic goals provide a more definitive program focus that ties critical, complex-wide requirements to site needs. The TFA will develop and execute its technology development tasks with these goals in mind.

Taken together, the full set of problem 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 problem element (described in Table ES.1) is directly associated with other technical activities funded by EM-30, EM-40, or EM-50. FY96 activities that may be leveraged or coordinated in FY97 have been identified and will be integrated into this plan as EM-30 and EM-40 complete their FY97 planning process. Table ES.2 shows the estimated EM-30, EM-40, and EM-50 funding for each of the problem elements. Additional details are provided in Section 3 of the MYPP.

In FY97, the TFA strategy will be to continue the process of integrating site technology and cross-cutting 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 risk-reduction needs presented in the *TFA FY 1996 Site Needs Assessment* (TFA 1996) and the program presented in the MYPP to identify high-impact risk-reduction, multisite activities that could be more efficiently performed through aggressive leveraging or coordination.

Programmatically, the strategic intent of the TFA is to be risk driven, fully integrated, fully leveraged, and responsive to user needs. Figure ES.2 illustrates a conceptual model of the TFA's strategic intent. A risk driven program recognizes environmental safety, and health risks to both workers and the public, cost and schedule risks, programmatic risks, and technical risks. Because the TFA is organized around problem elements that describe site technical needs instead of individual unit operations, the TFA achieves integration and the greatest multisite benefit from the resulting technology investments. Program leveraging is shown in Figure ES.2 with each element in the technology maturation cycle linked to elements on either side and to the DOE's industrial and international outreach programs. Risk-based prioritization of user needs ensures responsiveness at both site and complex-wide perspectives. Restated, the TFA strategic intent includes

- close work with EM-50's Risk Program, the tank site user programs, and STCGs to develop risk-based prioritization of needs and to make technology investments in response to those needs

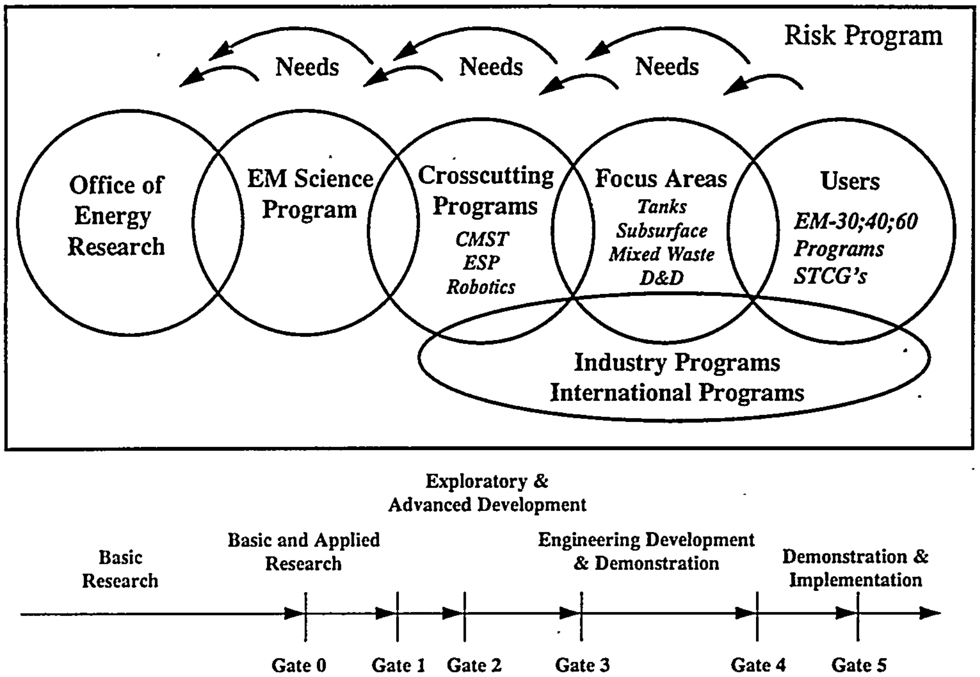

Figure ES.2. TFA Conceptual Strategy Model

- technology development for integrated multisite systems solutions
- leveraging every available science and technology investment made by DOE
- working in partnership with site users and stakeholders (through STCGs) to ensure the implementation of technology investments.

References

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

Tanks Focus Area (TFA). 1996. *TFA FY 1996 site needs assessment.* PNNL-11091, Pacific Northwest National Laboratory, Richland, Washington.

Table ES.1. Summary of TFA Technical Program

Problem Element	Problem Statement
1.1.1.1 Monitor Tank Integrity	There is a need to perform nondestructive examination of tank walls to determine structural integrity. Current methods are limited to contact examinations and usually require a cleaned surface and coupling between the head and structure being inspected. A real-time tank corrosion monitoring method is needed to provide early detection of potential problems that may lead to leakage or structural failure.
1.1.1.2 Avoid Tank Corrosion	Hanford, SRS, and ORR all have carbon-steel tanks with neutralized waste. These sites have reported leakage resulting from tank aging (corrosion). Tank leakage has occurred to a large extent in tanks that have not been heat treated. Corrosion in transfer lines at each site has been a safety issue as well as a transfer issue.
1.1.3.1 Characterize Waste In Situ	At Hanford, characterization of each full-length core is expensive and time consuming. The planning basis for core retrieval at Hanford is to retrieve over 400 full-length cores. In situ characterization would reduce costs, personnel radiation exposure, and generation of secondary radioactive waste streams. At INEL, characterization of the tank heels and residual waste or contamination may be required before the state and Federal agencies will grant closure permits.
1.1.3.2 Sample Waste	Currently applied auger, push, and coring technology is limited to vertical tank sludge/saltcake sampling directly under available risers. Most tanks are limited to one or two risers for sampling, insufficient to provide adequate samples for the horizontal profile of tank waste characteristics.
1.1.3.3 Analyze Waste	High cost and long time periods are required to conduct a complete suite of physical and chemical analyses on a tank waste cores. Development of remote analytical scanning technologies are needed to reduce the cost, time, personnel exposure, and generation of secondary waste when characterizing solid, radioactive core segments and samples from tank wastes.
1.1.4.2 Reduce Recycle Streams	Start up of treatment processes produces additional recycle and secondary waste streams that must be additionally treated before release to the wastewater treatment process and discharge. Technologies are needed to treat this moderately contaminated stream to prevent recycle to the full treatment process.

Table ES.1. (contd)

Problem Element	Problem Statement
1.2.1.1 Deploy Equipment	<u>Hanford</u>: Specific problems and needs associated with retrieval and closure of Tanks 104-AX and 106-C include: • Tank 104-AX sampling and survey requirements need to be determined. • Deployment systems suitable for the sampling and survey tasks for 104-AX need to be prepared for field use. <u>ORR</u>: As part of the Gunite and Associated Tanks-Treatability Studies, plan, design, execute, and operate a retrieval demonstration on one of the gunite tanks. As part of this closure demonstration, there is a need for an LDUA system. <u>INEL</u>: There is a need for an LDUA system to support characterization, safety, and retrieval functions. <u>Multisite System Deployment</u>: An entire class of needed technology must be obtained from industry, developed, adopted for tank use, and implemented at one or more sites to enable characterization, safety, and retrieval equipment to be deployed within the tanks, including • tank integrity and leak investigations • characterization sampling of wastes and in situ waste analysis • visual waste and tank inspection • tank mapping • interim stabilization • annulus inspection and cleaning • retrieval of heels and other hard-to-remove wastes • assisting in the removal of in-tank hardware • decontamination of empty tank • closure activities.
1.2.1.2 Mobilize Bulk and Heel Wastes	The DOE complex has horizontal and vertical cylindrical waste storage tanks that require remediation. Removal of bulk saltcake and sludge, saltcake heels, hard sludge heels, and possibly debris will be required. Alternative approaches to the hydraulic mining baseline are required for retrieval of the hard sludges, or bulk waste retrieval in leaking tanks where water use is restricted, as well as removal of debris and contaminated floor and wall segments. There is also a need for technical support for producing functions and requirements documents and prototypic hardware to allow sites to procure the right equipment.
1.2.1.5 Detect and Mitigate Leaks	Measurement of waste tank liquid levels can have accuracies on the order of 1,000s of gallons. Improved methods for leak detection are needed to prevent unplanned release of radioactive waste in the event leakage occurs during retrieval. Leakage during sluicing and other types of waste removal will be an issue with states, regulatory agencies, stakeholders, and sites. Two general types of leak prevention technologies, repair and mitigation, need to be investigated and alternatives evaluated.

Table ES.1. (contd)

Problem Element	Problem Statement
1.2.1.6 Monitor and Control Retrieval Process	In situ tank and transport line sensors to measure slurry density, mass flow, viscosity, and volume percent solids are needed. Retrieval and transfer activities in need of near-term slurry monitoring include ORR gunite and associated tanks and Hanford tanks undergoing retrieval as part of Hanford Tanks Initiative. A downselect of the appropriate monitors, installment, and field testing is needed before FY98 to provide validated, on-line slurry monitoring.
1.2.1.7 Integrate Retrieval and Pretreatment Technology Systems	A comprehensive methodology for matching the combination of technologies for a particular tank waste or blend of tank wastes is not available. An integrated tool is needed to ensure users can reliably evaluate alternative processing approaches and system configurations and compare them based on multiple criteria.
1.2.2.1 Calcine Waste	The INEL sodium-bearing waste is not compatible with the current fluidized bed calcination flowsheet at 500°C because of incomplete conversion of the nitrates to oxides and the formation of agglomerated particles in the calcine. Processing: Alternatives include high-temperature processing and sugar additive calcination to improve denitration. Process Monitoring: Development of real-time process control monitoring will be needed to 1) measure hydrocarbons in calcine offgas fines and 2) measure elemental species in the calcine product.
1.2.2.3 Prepare Retrieved Waste for Transfer and Pretreatment	Two primary issues exist: 1) sludge and saltcake chemistry and its impact on dissolution rates, pipeline transfers, and mixing operations, and 2) sludge physical properties and their impact on the pipeline transfer and mixing operations.
1.2.2.4 Clarify Liquid Stream	All four sites identified solid-liquid separation as a critical problem. Testing of alternative filter systems is required to support the separation of undissolved solids from the sodium-bearing and dissolved calcine wastes at INEL, the late wash precipitate at SRS, various liquid low-level waste streams at ORR including TRU sludges, and strontium/TRU-bearing retrieval solutions, supernatants, and wash solutions for phase I privatization at Hanford.

Table ES.1. (contd)

Problem Element	Problem Statement
1.2.2.5 Remove Radionuclides	Cesium Removal from Alkaline Wastes: At SRS, cesium must be removed from supernates before grouting. For ORR, performance and cost data from actual processing is needed to ensure that deployment of cesium removal using crystalline silicotitanate is appropriate. At Hanford, there is a need to ensure that technology can meet waste acceptance criteria. Radionuclide Removal from Acid Wastes: Solvent extraction technologies applicable to TRU elements including strontium, technetium, TRU, and cesium in INEL waste streams must be developed and tested. Technetium Removal from Alkaline Wastes: To meet performance requirements for the LLW form at Hanford, technetium must be removed from the supernate in select tanks before immobilization. Anion exchanges are less effective if non-pertechnetate forms of technetium are in solution. Technetium removal technologies and/or procedures that can address this non-pertechnetate problem must be developed and/or demonstrated on actual waste. Other Radionuclides Removal from Alkaline Wastes: In addition to the needs for removal of cesium and technetium from supernates at the four sites, needs also exist for improvements to or alternatives to the baseline removal processes for other radionuclides, especially strontium.
1.2.2.7 Process Sludge	Sludges at SRS, Hanford, and ORR will require processing to remove nonradioactive constituents that either adds to the volume of the resulting HLW (e.g., aluminum) or impacts immobilization processing (e.g. chromium, technetium, or phosphate). Technical problems and issues exist in three areas of sludge processing: performance data on the baseline enhanced sludge washing system, sludge washing chemistry, and continuous sludge processing.

Table ES.1. (contd)

Problem Element	Problem Statement
1.2.2.8 Prepare Pretreated Waste for Immobilization	Supernate Stream to Low-Level Waste Immobilization: Significant quantities of sodium hydroxide (caustic) will be required to store and retrieve HLW and leach sludges at Hanford and SRS. Addition of fresh caustic will significantly increase the quantity of waste requiring disposal. Sludge HLW Stream to HLW Immobilization: The current flowsheet at Hanford and SRS transports dilute and variable sludge directly to the vitrification system. The vitrification system must be over-sized to handle the excessive water and heat-load requirements. Commercial techniques are available for moisture and organic extraction, but this has not been evaluated for potential application on tank sludge.
1.2.3.1.1 Monitor and Control LLW Immobilization Process	A faster, cheaper method than neutron activation for technetium-99 analysis is needed for process control. On-line analysis would be needed to avoid producing TRU waste and analysis of Resource Conservation and Recovery Act metals would be needed to maintain metal concentrations below levels which would be considered a mixed waste. Many of the specified test methods were not developed for testing glass. Methods are needed to verify conformance with specifications before DOE takes custody of the products from the private sector.
1.2.3.1.3 Immobilize LLW Stream	Disposal of low-activity tank wastes is being approached very differently at individual DOE sites, and, in some cases, even within a single site. Specific technical issues and needs exist at the sites for selection of the most appropriate and acceptable waste forms.
1.2.3.2.1 Monitor and Control HLW Immobilization Process	After the immobilized waste form is produced, methods for acceptance inspection and testing of the waste form are needed to verify conformance with specifications before DOE takes custody of the products from the private sector.
1.2.3.2.2 Prepare Secondary Waste from Pretreatment	As with all ion-exchange resins, crystalline silicotitanate resin disposal may require subsequent processing. Specifically, ORR requires engineering performance and cost data on ion-exchange resin vitrification to support a decision on secondary waste crystalline silicotitanate resin disposal. A key technical issue with crystalline silicotitanate resin vitrification is the ability to incorporate significant waste quantity into the glass waste form.
1.2.3.2.3 Prepare Sludge Feed	Sludge mobilization and transfer are directly impacted by the selection of sludge feed processing operations. In vitrification facilities, the process is controlled through control of the feed composition. If melter feed is not well mixed, it will affect process and equipment reliability. Performance of the sludge feed system needs to be enhanced.

Table ES.1. (contd)

Problem Element	Problem Statement
1.2.3.2.4 Immobilize HLW Stream	<u>Advanced Materials for Vitrification at Hanford and SRS</u>: Corrosion of materials in specific environments has been observed. <u>Vitrification of INEL High-Activity Waste</u>: Technology for immobilization of the high-activity waste fraction must be identified and evaluated so that a plan and schedule for the waste treatment facility can be negotiated. <u>Advanced Immobilization Systems for Hanford</u>: Testing of alternative processes with representative waste simulants is needed to produce engineering performance and cost data to support final technology selection at Hanford. <u>Optimization of Glass Component Solubility</u>: For SRS tank wastes and much of the Hanford tank waste, the major waste components will determine the waste loading by affecting important process and product parameters. Methods are needed to increase the levels of these components which can be included in waste glasses.
1.2.3.2.5 Treat HLW Offgas	Effective control of vitrification processes, and a reliable design of process equipment, require an understanding of the interactions between feed composition and melter conditions. An understanding of these interactions is also essential for preventing or remediating corrosion problems in melter vapor space and offgas systems, and for optimizing waste loading in glass.
1.3.1.3 Define Closure Criteria	Hanford, SRS, and ORR are pursuing closure or preparation for closure of waste tanks during the FY96-99 time frame. A key issue is the definition of closure criteria and defining "how clean is clean?". At SRS, an evaluation of the variety of alternative closure options (in addition to grout over the waste) needs to be performed and source term conceptual models need to be developed. At Hanford, performance and cost-based closure criteria for Hanford's Tanks 104-AX and 106-C are needed that are acceptable to DOE, its regulators, and interested stakeholders.
1.3.1.7 Stabilize Tank for Closure	The Hanford Site needs knowledge and concepts to characterize the soil surrounding the waste tanks and to stabilize the waste tanks, if required, by • adding materials that preferentially capture and retain the radionuclides that contribute the most to the risk consequences of the waste residue in the tank • developing data on potential barrier performances that can reduce the water recharge rates to the stabilized tanks • developing concepts and designs that divert away any recharge water that penetrates the surface barrier.

DOE U.S. Department of Energy
HLW high-level waste
INEL Idaho National Engineering Laboratory
LDUA Light-Duty Utility Arm
LLW low-level waste
ORR Oak Ridge Reservation
SRS Savannah River Site
TRU transuranic

Table ES.2. Recommended Tec

Problem Element#	Problem Element Title	FY96[a] TFA	FY96[a] EM-50XC[b]	3
1.1.1.1	Monitor Tank Integrity			
1.1.1.2	Avoid Tank Corrosion			
1.1.3.1	Characterize Waste In Situ	575	809	
1.1.3.2	Sample Waste		127	
1.1.3.3	Analyze Waste	985	2,210	
1.1.4.2	Reduce Recycle Streams	350		
1.2.1.1	Deploy Equipment	6,540	1,075	
1.2.1.2	Mobilize Bulk and Heel Wastes	3,283		
1.2.1.5	Detect and Mitigate Leaks	600	500	
1.2.1.6	Monitor and Control Retrieval Process		775	
1.2.1.7	Integrate Retrieval and Pretreatment Technology Systems	300		
1.2.2.1	Calcine Waste			
1.2.2.3	Prepare Retrieved Waste for Transfer and Pretreatment			
1.2.2.4	Clarify Liquid Stream	1,183	208	
1.2.2.5	Remove Radionuclides	2,750	5,834	
1.2.2.7	Process Sludge	2,225		
1.2.2.8	Prepare Pretreated Waste for Immobilization	100	825	
1.2.3.1.1	Monitor and Control LLW Immobilization Process			
1.2.3.1.3	Immobilize LLW Stream	900		
1.2.3.2.1	Monitor and Control HLW Immobilization Process			
1.2.3.2.2	Prepare Secondary Waste from Pretreatment	755		
1.2.3.2.3	Prepare Sludge Feed			
1.2.3.2.4	Immobilize HLW Stream	500		
1.2.3.2.5	Treat HLW Offgas			
1.3.1.3	Define Closure Criteria	450		
1.3.1.7	Stabilize Tank for Closure			
	TOTALS	21,496	12,363	2

(a) Bases for funding estimates: Estimates were provided by the applicable program management as of second quarter, FY96. These estimates a

(b) EM-50XC = EM-50 crosscutting programs (Efficient Separations and Processing, Robotics, Characterization, Monitoring, and Sensoring Tec

All funding estimates are for planning purposes o nical Program Budget ($K)

	FY97[a]			FY98[a]			FY99[a]			
M- 0/40	FY97 TFA	EM-50XC[b]	EM-30/40	TFA	EM-50XC[b]	EM-30/40	TFA	EM-50XC[b]	EM-30/40	TOTAL
334	150			300			200			984
	350			200	600		800			1,950
3,638	450	265	2,200	250	3,000	3,000				14,187
		500		500	500		1,000			2,627
550	380		300	250	1,400					6,075
1,198				500			1,000			3,048
4,680	7,270	2,075	2,500	9,700	800	1,750	10,100			46,490
1,320	5,050		4,000	4,850	1,400	1,000	2,300			23,203
494	500	300		1,100	600		1,200			5,294
	200	1,240		900	800					3,915
	600			600			200			1,700
2,835	600		2,745	650		2,808	500			10,138
984	400			1,150		1,000	1,700			5,234
1,420	1,400		394	250			400			5,255
1,931	2,490	2,950	549	5,200	2,800		4,500			29,004
2,412	2,750		250	3,700			2,400			13,737
	500	875		600	400		1,400			4,700
1,318	500		250	1,600		250	1,600			5,518
1,260	1,300		1,371	2,350		1,125	2,350			10,656
				600			600			1,200
	2,000			200						2,955
1,847			760	400	2,250	50	200			5,507
1,458	450		535	2,900			2,500			8,343
250	150			150						550
305	2,280		1,000	1,150						5,185
	700			600			1,000			2,300
3,234	30,470	8,205	16,854	40,650	14,550	10,983	35,950			219,755

e subject to change as the programs change.

nology), including industry and universities.

ly and are not official funding information.

Contents

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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 (FY97-FY99), with an emphasis on FY97 and FY98. In addition to describing the processes used to develop the program (Section 2), this document also defines the technical strategies and the recommended TFA program (Section 3), the programmatic and 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 sites (Appendix A), details on baseline assumptions and the problem elements (Appendix B), and a glossary (Appendix C).

1.1 Program Background

DOE faces a major tank remediation problem. Approximately 332 tanks are used to store over 378,000 m^3 of high-level waste (HLW) and transuranic (TRU) waste across the DOE complex. Most have significantly exceeded their life spans. Approximately 90 tanks 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: Hanford Site, Richland, Washington; Idaho National Engineering Laboratory (INEL), Idaho Falls, Idaho; Oak Ridge Reservation (ORR), Oak Ridge, Tennessee; and Savannah River Site (SRS), Aiken, 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 Management (EM) has an estimated FY96 budget of about $62 million for technology development to remediate tank waste. This money is funded out of 11 organizations and supports several hundred separate activities addressing a variety of problems across the four tank sites. A TFA challenge is to influence, coordinate, and integrate a high-level tank waste remediation technology development program. Each site has specific requirements, yet, due to limited funding, technology development progress at any one site must be leveraged throughout the DOE complex. The magnitude of this challenge is viewed better when considering the high-level tank waste remediation life cycle costs at the four sites. In 1996 constant dollars, the total cost is nearly $60 billion. Figure 1.1 shows this distribution graphically, with details for each site presented in Appendix A.

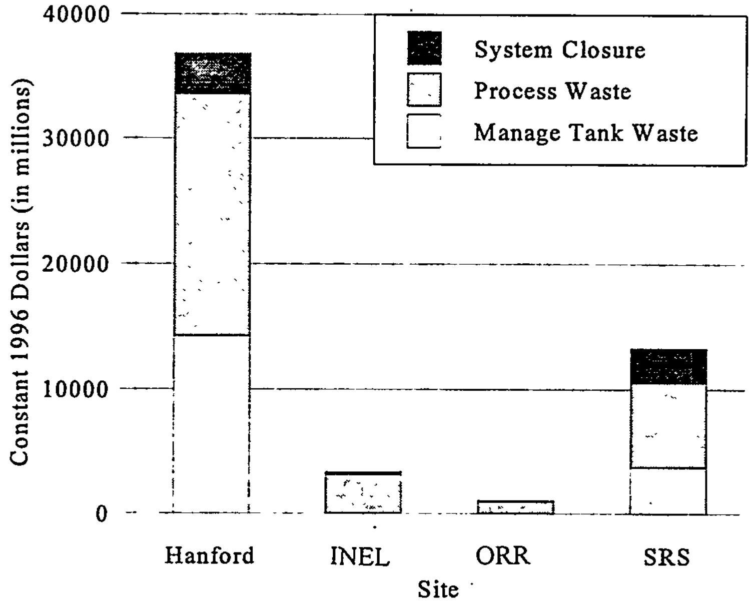

Figure 1.1. High-Level Tank Waste Remediation Life-Cycle Costs by Site

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 complex. 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 National Laboratory serves as the lead technical organization of the TFA Technical Team. This team is composed of 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, coordinating the efforts of other site field activities through site representatives and Site Technology Coordination Groups (STCGs).

The Technical Team is guided by a User Steering Group (USG) composed of senior managers of the site tank remediation programs. The technical program is reviewed by the TFA Technical Review Group, which is composed of technical experts from the national laboratories and universities.

The TFA began operations in October 1994. Its mission is to manage the development and demonstration of technologies using an integrated approach to safely and efficiently accomplish tank waste remediation across the DOE complex. 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, ORR, and SRS. 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 Science and Technology (EM-50). In the future, the TFA will integrate activities across and beyond the DOE complex.

1.3 TFA Strategies and Goals

The TFA has greatly increased its awareness of DOE complex-wide high-level tank waste remediation needs, the state of technologies to satisfy those needs, and the roles played by various users, developers, and producers. Through this deeper awareness, the TFA developed both the technical and programmatic strategies and goals that appear in this MYPP.

1.3.1 Technical Strategies and Goals

Technical strategies exist for each major problem area intended for direct TFA funding. The strategies consider work by others that the TFA may leverage (Section 3). The TFA's technical goals strive to meet the challenges of providing waste retrieval systems, pretreatment and immobilization technologies, subsystems support to tank closure activities, and demonstration of compact processing units.

1.3.2 Programmatic Strategies and Goals

During its first year, the TFA was committed to deliver a technology program that was

- applicable - addressed users' needs and was implemented within budget, schedule, and regulatory constraints
- integrated - leveraged relevant activities across EM-30, EM-40, EM-50, and across and beyond the DOE complex
- acceptable - had broad involvement of key stakeholders and incorporated expertise from outside the laboratory system (e.g., from industry and universities)
- accountable - performed within budget and on schedule and produced a clear benefit.

At the same time, the technologies provided by this program were to

- reduce the technical risks that jeopardized baseline tank remediation performance requirements

- reduce the programmatic risks that 1) jeopardize the sites' ability to comply with regulatory or stakeholder drivers that were not formalized in baseline plans or 2) limit the sites' 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 has made great progress toward fulfilling goals. The interest and participation by the four sites made possible a full discussion of key issues, the identification of cross-site technology integration opportunities, and the collection of a wealth of user input and guidance. The TFA appreciates the invaluable contributions of site representatives, stakeholders, and TFA team members in industry, universities, and throughout the DOE laboratory system. The TFA believes these goals are applicable until the high-level tank waste remediation task is complete. With continued participation of present partners, and new partners expected in the future, the program will provide even greater cost and risk reduction benefits. This MYPP highlights progress during the past year and the updating of the plans for the next 3 years of the program.

Several programmatic strategies have developed since the publication of the previous MYPP. These include performer selection, alternative site technology baseline management strategies, and TFA linkages with users, other stakeholders, and other focus areas. These strategies are summarized in Sections 2 and 4.

1.4 Organization of Multiyear Program Plan

The MYPP consists of the following sections. Section 2 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 3 introduces technical strategies that describe a framework within which the TFA has recommended its focus for the next 3 years. It includes a TFA overview and describes the baseline recommendation. The baseline recommendation consists of activities with 26 problem elements. The problem elements were developed by the TFA Technical Team based on a process and systems-oriented view of high-level tank waste remediation. The problem elements address broad-impact multisite needs, describe the technical problem underlying each need, and map a path to resolve the technology development components. Each problem element also contains FY97-99 budget and scope projections. Detailed schedules and performance indicators will be presented in the TFA FY97 work plan. Section 4 describes the program objectives and implementation. Section 5 lists the references used in writing this report.

Several appendices are attached. 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 problem elements. Each description includes a problem statement, general work scope for FY97-99, 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 - Program Development Process

The process being used to develop the TFA technical program consists of four iterative steps (Figure 2.1). 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 2.2.

- **Needs Assessment** (November 1995-March 1996) - The TFA asked the STCGs at each of the four tank sites to identify and update their technology needs for tank waste remediation. This step helped assure the TFA technical program maintains its firm foundation in site needs, as defined by the sites. The TFA cataloged the needs within the previously developed needs breakdown structure, but later prepared a program element structure that more logically packaged the needs for the program definition step. Collected needs were first cataloged to more easily identify needs that applied across multiple sites. Each need was formally evaluated based on priorities provided by each site, as well as cost reduction potential, confidence that satisfaction of the need would increase the sites' ability to remediate their tanks, and DOE complex-wide benefit. Needs fulfilling these criteria were labeled "high-impact." High-impact needs were then grouped to provide the program definition framework for the construction of technology responses. Comprehensive information on tank site needs has been compiled in the *TFA FY 1996 Site Needs Assessment* (TFA 1996).

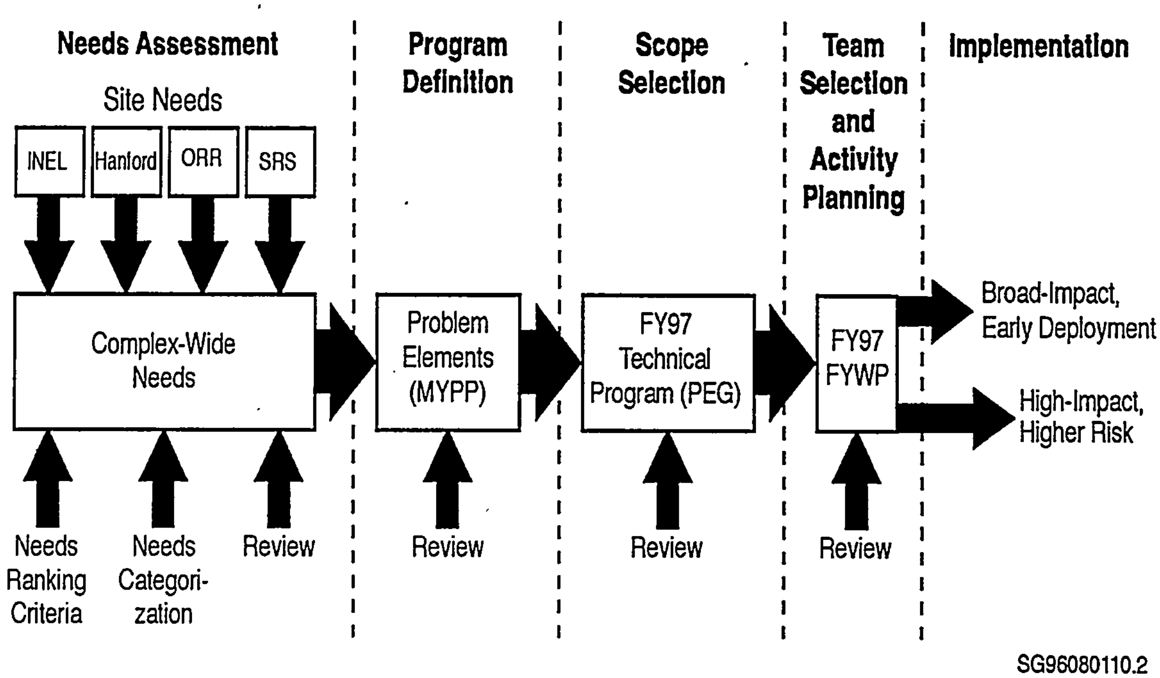

Figure 2.1. TFA Program Development

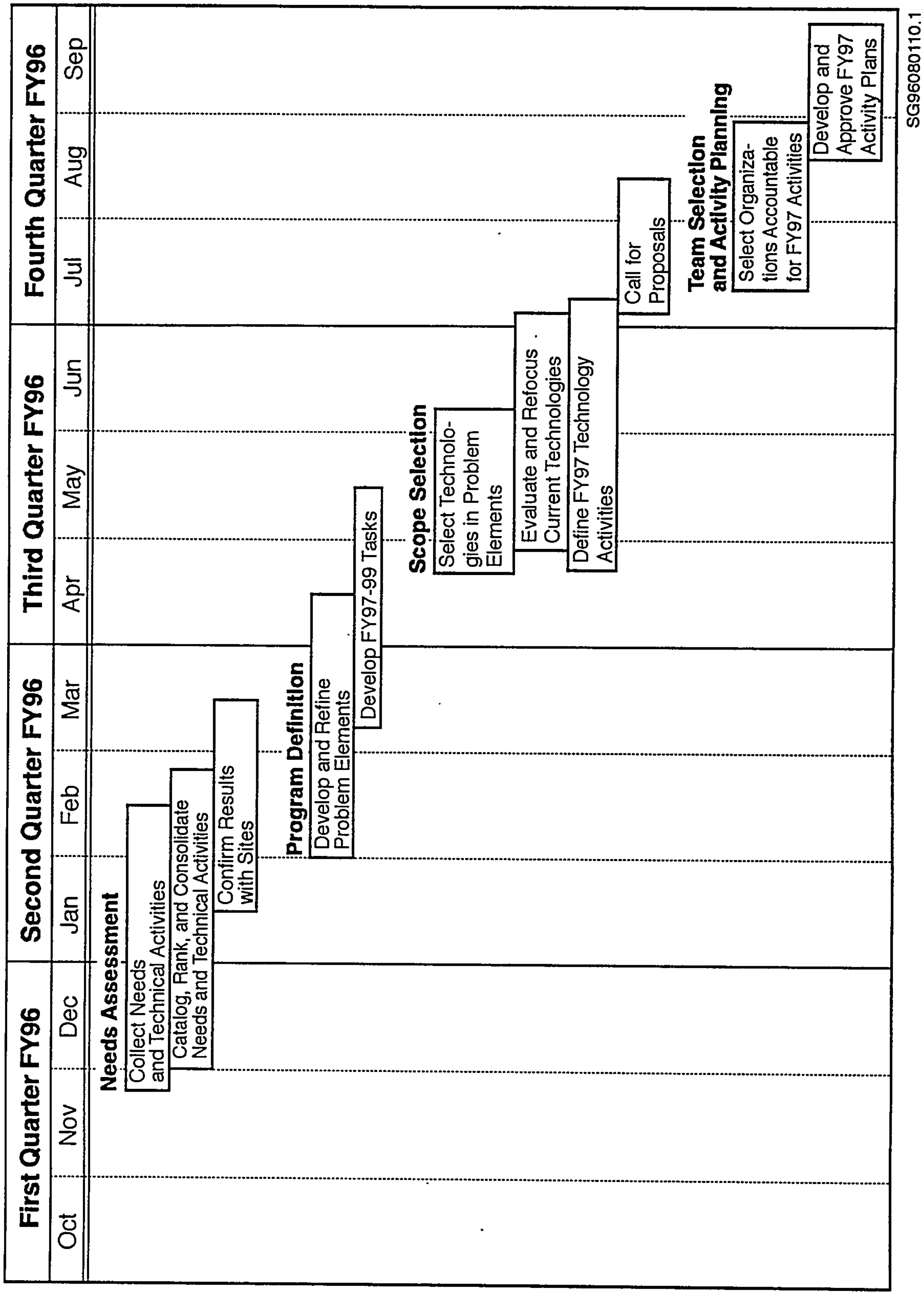

Figure 2.2. TFA Program Development Process

- **Program Definition** (February-May 1996) - Focusing on the high-impact needs, the TFA assessed the similarities between needs and the sites' schedule requirements for matching technical responses. This assessment included those technical responses presently underway in FY96 that are expected to continue into the FY97-99 period. For the FY98 program, the TFA consolidated, where appropriate, site needs within the problem element structure. These groupings permitted development of initial problem definitions, general work scopes, and anticipated major milestone and schedule events. Using preliminary DOE budget guidance, the TFA developed the FY98 technical response, prioritizing each anticipated task. The TFA referred to the needs assessment process in prioritizing the tasks and involved the sites in validation of the results.

- **Scope Selection** (May-June 1996) - The initial scope and schedule for each FY97 technical task were established during this same process last year. These were updated during the program execution guidance process that occurred during June-July 1996. These reviews included site representatives, STCGs, the TFA USG, and the TFA Technical Review Group. For new tasks to start in FY98, the TFA will update the initially-developed scopes throughout the year, culminating in the same process to be used for FY97 tasks.

- **Team Selection and Activity Planning** (July-September 1996) - The TFA 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 FY97 work plan. Final plans for calls for proposals will be completed and executed in time to initiate work when funds are available after October 1, 1996.

Each of these steps has been or will be reviewed for both programmatic and technical validity. The TFA is guided by a USG. The USG, STCGs, and other site representatives have been full partners in both the TFA needs assessment and the selection of high-impact needs. To ensure technical validity, the TFA Technical Review Group, composed of technical experts in each of the primary program areas, peer-reviews the TFA technical program. See Section 2.5 for more information on the peer review process.

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 through technology maturity levels. Beginning in FY97, the TFA will place increasing emphasis on management of technology maturity levels. Each proposed task performed during FY97-99 has been placed within the appropriate maturity level to facilitate active management to the next level. This MYPP will be updated and revised annually to reflect these changes.

2.1 Needs Assessment

To ensure that TFA technologies address site needs, Hanford, INEL, ORR, and SRS were each asked to provide needs data. Last year, the TFA conducted an extensive needs collection effort. This year, the TFA provided each site with last year's input, asking that the needs either be validated, modified, or deleted. This was in addition to the submission of newly generated needs. INEL, ORR, and SRS used last year's needs submission as a starting point. Hanford created an all new set of needs via the STCG. The needs provided by the sites reflected the schedule and budget assumptions of site-specific planning baselines and were rated by the sites as to their priority.

2.1.1 Needs Ranking and Validation

The four sites contributed a total of 273 needs, and the TFA added 14 more covering various complex-wide requirements, for a total of 287 needs. The TFA's task was to identify those tasks that represented high complex-wide impact. From the full range of site needs collected, the TFA identified the high-impact set of needs by evaluating each site need against the following criteria.

- Site priority - Needs identified by the sites as high, medium, or low priority retained those same rankings. The TFA assumed sites considered the urgency of need in their rankings, including responses to regulatory commitments.

- Cost reduction - Needs with an estimated savings of $250 M were rated high, between $250 M and $50 M were rated medium, and less than $50 M were rated low.

- Confidence - The TFA estimated whether research and development responsive to each need would increase the confidence that the site would manage or remediate its tank waste effectively.

  - "High" corresponded to needs for which a site could not proceed without a solution.

  - "Medium" corresponded to needs where there was a possibility that cleanup would be delayed if the need was not met.

  - "Low" corresponded to needs where a solution would help the site, but cleanup activities would continue without a solution.

- Broad-based - Solutions to each need could be deployed at more than one site or with multiple tanks at a single site.

  - "High" was given if all sites had the same need.

  - "Medium" was given if two or three sites had the same need.

  - "Low" was given if only one site had the need.

Following TFA Technical Team's analysis, the USG reviewed the results and recommended additional actions. Following their review, a set of 144 high-impact needs were provided to each site, and teleconferences were conducted during February 1996 to identify site issues, clarify needs, and pose questions for TFA response. Following these reviews, 130 high-impact needs remained.

2.1.2 Needs Cataloging - The Transition to Program Definition

For proposed work in FY98 and beyond, the TFA cataloging process served to focus each need into groupings tied to key problems for the sites. The groupings, or elements, were not based on technical focus, but integrated across functions to solve specific problems. The goal was to look across need elements for common problems that could take advantage of the same technical solutions and build off of each site's schedule. Therefore, the TFA modified the needs breakdown structure approach used last year to catalog needs. In the place of the needs breakdown structure, problem elements provided a simpler, more closely tied structure representing tank waste remediation areas of concern.

The TFA placed each of the 130 high-impact needs into the problem element structure, permitting a more system-wide view of the technical areas of concern to the sites (see Table 2.1). In considering site-provided schedules and drivers with the needs in the problem element structure, the TFA began shaping a technical program.

2.2 Program Definition

The objective of this year's program development process was the preparation of a "right program" for FY98. The TFA defines the right program as one

- created by and traceable to individual site needs
- prioritized in cooperation with the sites
- proposed for funding by need rather than by anticipated budget.

Beginning with the problem element structure populated with individual site needs, the TFA examined the similarities between needs within the structure elements. Considering whether each need required a baseline, enhancement, or alternative technology response, similar needs with compatible schedules were formed into workable project tasks. Adding FY97 tasks into the problem elements, and projecting tasks continuing into FY99, the TFA viewed the program from a multiyear perspective.

Once the program was defined, the EM-50 tanks technology budget for FY98 was allocated across the work packages that contained tasks responding directly to site needs. Enhancement opportunities and longer-term, higher-payoff technologies were then allocated budgets commensurate with their projected scope and schedules. The allocation ensured that the most urgently needed technologies were supported on a schedule to meet site needs.

A detailed description of each problem element is provided in Appendix B. The descriptions include a detailed problem statement, a recommended path to solution, a discussion of technical issues, FY97-99 scope, the FY96 budget, and FY97-99 requested budgets.

2.3 Scope Selection

During last year's program definition process, specific tasks were scoped for each technical element once the technical elements of the program were defined. This year, reflecting the TFA's needs-driven approach, specific tasks were identified to meet complex-wide needs, then fit into the problem element structure supporting the program development process. Next, the TFA prepared an integrated description of each problem element containing one or more tasks. The TFA defined the basic technical problem requiring solution and a general scope description of the approach for FY97-99. Further, the TFA formulated anticipated major schedule or milestone events during the period, and funding required to support the described scope. For FY97, the scopes are presented in the TFA FY97 program execution guidance.

To complete scope selection, the TFA will

- continue to call for proposals, as funding permits, to address program gaps as they develop, 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 reducing the scope of activities that are poorly matched to user needs.

2.4 Team Selection and Activity Planning

Once the scope of the technical elements and site technical activities has been defined and appropriately focused, the TFA 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), cost reduction potential, 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 TFA Technical Team will facilitate the selection of accountable organizations, supported by the TFA Technical Review Group, and confirmed by the TFA Management Team.

Three strategy guideposts, or key drivers, characterize the TFA's performer selection and call for proposals logic. First, the TFA is committed to engage the "best and brightest" performers, whether they are from the public or private sector. Second, in keeping with EM's interest to gain and maintain a commitment to commercialization, the TFA prefers a bias toward private industry. Lastly, the selection of performers is subject to the practical constraints of opportunity and access to tank sites and radioactive tank waste samples.

The FY97 program execution guidance represents ongoing, continuing work, as well as new starts. Continuing work includes work conducted by a principal investigator who has been funded by any organization within the DOE where the work scope is being transferred to or leveraged by the TFA. Continuing work may be significantly rescoped to reflect updated site needs or address technical issues that surfaced in the previous year. For continuing work, the TFA's philosophy is to retain performing organizations, provided performance has been satisfactory. Satisfactory performance measures include successes in meeting scheduled milestones and staying within budget constraints. Work that has not been satisfactorily performed is considered for reissue to another performer. The selection process for the performer is the same as if the work was a new start.

For new starts, the first consideration is an assessment of possible constraints. Constraints include the need for special facilities or equipment, requirements for radioactive wastes, special access, transportation needs, or urgent time lines that preclude the possibility of a call to industry (~180 days to place). If no constraints exist, the TFA may elect to solicit industry or academia directly. However, should constraints exist, the TFA's default is to offer the work to the national laboratory system. For unconstrained tasks, the primary consideration is for industry participation.

The TFA's decision to offer certain work to national laboratories does not preclude eventual participation by industry and academia. The TFA encourages laboratories to establish outside partnerships and teaming arrangements. However, the TFA leaves this decision to the performing laboratory or principal investigator.

Activity planning is critical to both selection of accountable organizations and FY97 work authorization. Activity plans must be prepared in sufficient 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 FY97 technical program and will be documented in the FY97 work plan.

2.5 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 Technical Review Group, and the STCGs.

The USG was established to provide user input from a site tank waste remediation management perspective. It is comprised of senior managers of the four tank site remediation programs and acts as a board of directors to the TFA Implementation Team. Members have participated in the initial planning, data collection, and validation phases of the site needs assessment. The USG is responsible for

- providing assistance to the Technology Integration Managers in establishing effective technical support networks and work locations at the sites and to the Program Integration Manager in accessing site information on technology drivers, needs, facilities, and programs

- approving the TFA Technical Team's recommended MYPP before submittal to DOE

- providing active support for transitioning current site-based technology programs to the TFA and then transferring demonstrated technologies back to these sites.

The TFA Technical Review Group was established to review both the processes and products of the TFA. It is composed 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 Technical Review Group met once to review ongoing work in FY96 and provide guidance for technical activities to meet needs during the FY97-99 period. 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.

During FY96, members of the TFA Technical Review Group participated in three separate calls for proposal evaluations. The group provides the TFA with an unbiased, highly qualified technical evaluation source. Additionally, the TFA Technical Review Group's participation in proposal evaluations keeps the group members involved and up-to-date with TFA activities throughout the year. The TFA will continue to use members of the review group in proposal evaluations in the future.

The STCGs will facilitate site reviews of TFA programs and technology deployment at each of the sites. STCGs are composed 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 2.1. High-Impact Needs and Problem Elements

Site Need	Problem Element
169 - Develop "Fly By" NDE Inspection System/Idaho	1.1.1.1 Extend Tank Life - Monitor Tank Integrity
363 - Issues with Safe Operation, Decon, and Removal of Tank End Effectors/Idaho	
382 - Develop Real-Time Corrosion Monitoring Techniques/SRS	
601 - Extension of Carbon Steel Tank Life and Minimizing the Impact to Processing/TFA	1.1.1.2 Avoid Tank Corrosion
514 - Develop Mechanisms and/or Devices to Passively Ventilate Hydrogen and Other Potentially Combustible Vapors from HLW Tanks/SRS	1.1.2 Ventilate Tanks
357 - Field Methods for 3D Mapping of Waste Chemical and Radiological Properties/Oak Ridge	1.1.3.1 Characterize Waste In Situ
399 - Develop In Situ Sensor to Identify Flammable Gas Species/Idaho	
486 - In Situ Characterization Capability (Minilab)/Idaho	
531 - Development of Direct/Indirect In Situ Waste Energetics Measurement Capability/Hanford	
532 - Instrumentation to Remotely Monitor Low (<5 wt%) Waste Moisture Concentrations/Hanford	
541 - In Situ Core Drilling-Speciation/Hanford	
530 - Off Riser Sampling/Hanford	1.1.3.2 Sample Waste
595 - Waste Characterization for Tc/TFA	1.1.3.3 Analyze Waste
596 - Waste Characterization Strategy (Physical/Chemical) to Support Processing Needs/TFA	
102 - Concentrate Waste - Reducing Water Volume of DWPF/SRS	1.1.4.2 Reduce Recycle Streams
303 - DWPF Recycle Stream Flow and Composition/SRS	
309 - Methods for Recycle Minimization/SRS	
64 - Heel Waste Retrieval - Vehicle/Oak Ridge	1.2.1.1 Deploy Equipment
187 - Heel Waste Retrieval/Characterization - LDUA Deployment Systems/Oak Ridge	
346 - Bulk Sludge Mobilization and Slurry Transport - Alternative Mechanical Mobilization Systems/Oak Ridge	
347 - Heel Waste Retrieval - WD&C/Oak Ridge	
363 - Issues with Safe Operation, Decon, and Removal of Tank End Effectors/Idaho	

Table 2.1. (contd)

Site Need	Problem Element
364 - Issues with Safe Removal, Decon, and Insertion of Retrieval Devices/Oak Ridge	1.2.1.1 Deploy Equipment (contd)
365 - Issues with Safe Removal, Decon, and Insertion of Retrieval Devices/SRS	
371 - Develop Inspection Technologies for Type I & II Tank Annulus/SRS	
423 - Develop Removal Techniques for Mired Equipment/SRS	
445 - Heel Waste Retrieval/Characterization - LDUA Deployment Systems/Idaho	
530 - Off Riser Sampling/Hanford	
602 - Develop Strategy, Requirements, and Needs for Deployment in Tanks/TFA	
343 - Bulk Sludge Mobilization and Slurry Transport - Mix & Mobilize Sludge/Oak Ridge	1.2.1.2 Mobilize Bulk and Heel Wastes
346 - Bulk Sludge Mobilization and Slurry Transport - Alternative Mechanical Mobilization Systems/Oak Ridge	
347 - Heel Waste Retrieval - WD&C/Oak Ridge	
374 - Develop Simulants/Idaho	
375 - Develop Simulants/Oak Ridge	
421 - Outline Mix Requirements and Pump Configuration for Salt Dissolution/Sludge Removal/SRS	
422 - Improve Salt Mining Equipment and Techniques/SRS	
430 - Develop Method to Address Insoluble Solids in Salt Tanks/SRS	
431 - Develop Method to Remove Mixed Salt and Sludge/SRS	
432 - Develop Method to Remove Dry/Hardened Sludge/SRS	
436 - Develop Method to Remove Tank Heels/SRS	
439 - Develop Improved Slurry Pumps to Minimize Addition of Inhibited Water/SRS	
448 - Retrieve Calcine From Bins/Idaho	
487 - Develop Simulants/SRS	
534 - Waste Retrieval Methods Needed for DST Waste Not Amenable to Advanced Design Mixer Pump Retrieval/Hanford	
535 - SST Retrieval Equipment/System Development/Hanford	

Table 2.1. (contd)

Site Need	Problem Element
569 - Settle Decant Demonstration for Solid-Liquid Separations/Hanford	1.2.1.2 Mobilize Bulk and Heel Wastes (contd)
575 - Simulant (Retrieval Process Test Material) Development/Hanford	
343 - Bulk Sludge Mobilization and Slurry Transport - Mix & Mobilize Sludge/Oak Ridge	1.2.1.3 Mix Waste
346 - Bulk Sludge Mobilization and Slurry Transport - Alternative Mechanical Mobilization Systems/Oak Ridge	
347 - Heel Waste Retrieval - WD&C/Oak Ridge	
374 - Develop Simulants/Idaho	
375 - Develop Simulants/Oak Ridge	
421 - Outline Mix Requirements and Pump Configuration for Salt Dissolution/Sludge Removal/SRS	
422 - Improve Salt Mining Equipment and Techniques/SRS	
431 - Develop Method to Remove Mixed Salt and Sludge/SRS	
432 - Develop Method to Remove Dry/Hardened Sludge/SRS	
439 - Develop Improved Slurry Pumps to Minimize Addition of Inhibited Water/SRS	
448 - Retrieve Calcine From Bins/Idaho	
487 - Develop Simulants/SRS	
534 - Waste Retrieval Methods Needed for DST Waste Not Amenable to Advanced Design Mixer Pump Retrieval/Hanford	
535 - SST Retrieval Equipment/System Development/Hanford	
575 - Simulant (Retrieval Process Test Material) Development/Hanford	
185 - Bulk Sludge Mobilization and Slurry Transport - Slurry Transport Studies/Oak Ridge	1.2.1.4 Transfer Waste
343 - Bulk Sludge Mobilization and Slurry Transport - Mix & Mobilize Sludge/Oak Ridge	
346 - Bulk Sludge Mobilization and Slurry Transport - Alternative Mechanical Mobilization Systems/Oak Ridge	
347 - Heel Waste Retrieval - WD&C/Oak Ridge	
374 - Develop Simulants/Idaho	
375 - Develop Simulants/Oak Ridge	

Table 2.1. (contd)

Site Need	Problem Element
405 - Develop Improved Pump Testing and Maintenance Program/SRS	1.2.1.4 Transfer Waste (contd)
422 - Improve Salt Mining Equipment and Techniques/SRS	
431 - Develop Method to Remove Mixed Salt and Sludge/SRS	
432 - Develop Method to Remove Dry/Hardened Sludge/SRS	
439 - Develop Improved Slurry Pumps to Minimize Addition of Inhibited Water/SRS	
448 - Retrieve Calcine From Bins/Idaho	
487 - Develop Simulants/SRS	
575 - Simulant (Retrieval Process Test Material) Development/Hanford	
384 - Develop Leak Repair Techniques/SRS	1.2.1.5 Detect and Mitigate Leaks
544 - Tank Leak Mitigation Systems/Hanford	
345 - Bulk Sludge Mobilization and Slurry Transport - In-Line Solids Monitoring/Oak Ridge	1.2.1.6 Monitor & Control Retrieval Process
482 - On-Line Monitoring Waste Retrieval Process/Oak Ridge	
555 - Real Time Waste Property Measurement System for Waste Transfer/Hanford	
594 - Develop Strategy and Method for Managing Interface Between Functions/TFA	1.2.1.7 Integrate Retrieval and Pretreatment Technology Systems
597 - Waste Handling at the Interface with Retrieval and Immobilization/TFA	
162 - Retrieval: Robotics, Mixer Pumps, Waste Dislodging and Conveyance/Idaho	1.2.1.8 Mobilize Heel
437 - Tank Clean and Closure/SRS	
475 - Tank System Closure Demonstration/Oak Ridge	
528 - Tank Closure Demonstration for an Arid Site/Hanford	
501 - Alternative Calcination Process Flowsheet/Idaho	1.2.2.1 Calcine Waste
502 - On-Line Process Monitor for Elemental Analysis of Calcine Product/Idaho	

Table 2.1. (contd)

Site Need	Problem Element
591 - Prevent/Remediate Foaming in Process Vessels/TFA	1.2.2.3 Prepare Retrieved Waste for Transfer and Pretreatment
597 - Waste Handling at the Interface with Retrieval and Immobilization/TFA	
598 - Waste Chemistry/TFA	
9 - Removal of Undissolved Solids from Tank Waste & Dissolved Calcine/Idaho	1.2.2.4 Clarify Liquid Stream
97 - Late Wash Precipitate - Clarification of Liquid Streams/SRS	
176 - Liquids/Solids Separations Studies/Oak Ridge	
403 - Optimize Transfer Jet Performance/SRS	
563 - Demonstrate Filtration for Pretreatment Solid-Liquid Separations/Hanford	
569 - Settle Decant Demonstration for Solid-Liquid Separations/Hanford	
247 - Removal of TRU, Sr, Tc, Cs from Tank Waste & Dissolved Calcine/Idaho	1.2.2.5 Remove Radionuclides
489 - LLLW Supernatant/Oak Ridge	
495 - Sr, Tc, and Ru Removal/Oak Ridge	
498 - Source Treatment/Oak Ridge	
519 - Evaluate Ion Exchange or Precipitation Methods to Selectively Remove Cesium from High Potassium Salts/SRS	
533 - Technetium Removal/Hanford	
539 - Demonstration of TRU/^{90}Sr Removal/Hanford	
562 - Demonstrate Cs Removal for Hanford Supernatants/Hanford	
597 - Waste Handling at the Interface with Retrieval and Immobilization/TFA	1.2.2.8 Prepare Pretreated Waste for Immobilization
598 - Waste Chemistry/TFA	
600 - Reduce Volume of LLW by Sodium Nitrate Recovery/TFA	
178 - Sludge Separations/Oak Ridge	1.2.2.7 Process Sludge
518 - Develop Counter-Current Decantation Process for Sludge Washing/SRS	
538 - Pretreatment Demonstration for Phase I Sludges/Hanford	
553 - Pretreatment Demonstration for Phase II HLW Sludges/Hanford	
574 - Continuous Sludge Leaching and Processing Reactors/Hanford	

Table 2.1. (contd)

Site Need	Problem Element
517 - Develop Electrochemical Treatment of Salt Solutions for Caustic Recovery and Recycle/SRS	1.2.2.8 Prepare Pretreated Waste for Immobilization
570 - LLW - Separable Phase Organics/Hanford	
585 - Cost Effective Caustic Recycle/Hanford	
591 - Prevent/Remediate Foaming in Process Vessels/TFA	
597 - Waste Handling at the Interface with Retrieval and Immobilization/TFA	
598 - Waste Chemistry/TFA	
599 - Concentration of Sludge Prior to Immobilization/TFA	
94 - Characterization Methods for Tc-99 and I-129/Oak Ridge	1.2.3.1.1 Monitor & Control LLW Immobilization Process
529 - Waste Acceptance Testing/Hanford	
549 - LLW - On-Line Analysis/Hanford	
593 - Identification of Technology Gaps to Support Privatization/TFA	1.2.3.1.2 Prepare LLW Feed
594 - Develop Strategy and Method for Managing Interface Between Functions/TFA	
252 - Develop Grout Process for Sodium-Bearing Waste/Idaho	1.2.3.1.3 Immobilize LLW Stream
492 - Waste Form Acceptance/Oak Ridge	
493 - Sludge Waste Form Study/Oak Ridge	
494 - Sludge Waste Form Demonstration/Oak Ridge	
524 - Evaluate LLW Vitrification as an Alternative to Saltstone/SRS	
543 - LLW - Offgas Treatment/Hanford	1.2.3.1.4 Treat LLW Offgas
594 - Develop Strategy and Method for Managing Interface Between Functions/TFA	
285 - DWPF Analytical Methods for Attainment/SRS	1.2.3.2.1 Monitor & Control HLW Immobilization Process
287 - Improve DWPF Level Probes/SRS	
529 - Waste Acceptance Testing/Hanford	
189 - Secondary Waste Immobilization Studies/Oak Ridge	1.2.3.2.2 Prepare Secondary Waste from Pretreatment
558 - Process for Immobilization of Tc-Rich Waste Stream/Hanford	
567 - Crystalline Silicotitanate in HLW Glass/Hanford	

Table 2.1. (contd)

Site Need	Problem Element
66 - Prepare Melter Feed - Enhance Pumping/Mixing/SRS	1.2.3.2.3 Prepare Sludge Feed
266 - DWPF Flowsheet Model/SRS	
269 - Effects of Irradiation on Precipitate/SRS	
310 - Determine Maximum H_2 Evolution/SRS	
316 - Reduce Noble Metal Deposition/SRS	
520 - Optimize Waste Loading for DWPF Glass/SRS	
521 - Identify Alternates to Formic Acid for Melter Feed Redox Adjustment to Reduce H_2 and NH_3 Formation/SRS	
523 - Demonstrate Process for Amalgamation of Mercury which Results in a Nonhazardous Waste/SRS	
554 - Waste Loading Optimization for HLW/Hanford	
593 - Identification of Technology Gaps to Support Privatization/TFA	
594 - Develop Strategy and Method for Managing Interface Between Functions/TFA	
1 - Develop HLW Formulations for the High Activity Fraction of SBW and Calcine/Idaho	1.2.3.2.4 Immobilize HLW Stream
4 - Process Control Limits and Model Development for Waste Immobilization/Idaho	
5 - Integrated Demonstration of Immobilization Equipment/Idaho	
315 - Extend Operating Life of DWPF Melter/SRS	
316 - Reduce Noble Metal Deposition/SRS	
501 - Alternative Calcination Process Flowsheet/Idaho	
542 - Radioactive HLW Vitrification Tests - Phase I/Hanford	
561 - Radioactive Small-Scale Vitrification Demonstration (HLW-13)/Hanford	
592 - Smaller, Cheaper Melters/TFA	
282 - Cold Cap/Offgas Thermodynamics Model/SRS	1.2.3.2.5 Treat HLW Offgas
594 - Develop Strategy and Method for Managing Interface Between Functions/TFA	
169 - Develop "Fly By" NDE Inspection System/Idaho	1.3.1.1 Monitor Tank

Table 2.1. (contd)

Site Need	Problem Element
445 - Heel Waste Retrieval/Characterization - LDUA Deployment Systems/Idaho	1.3.1.2 Characterize Heels
165 - Determination of a Generalized Risk-Based Closure Criteria/Idaho	1.3.1.3 Define Closure Criteria
435 - Determine Zeolite Removal Requirements/SRS	
437 - Tank Clean and Closure/SRS	
454 - Stabilization and Closure Analysis Tools/SRS	
455 - Establish Clean-Up Standard/Criteria/Oak Ridge	
459 - Data for Closure/SRS	
475 - Tank System Closure Demonstration/Oak Ridge	
528 - Tank Closure Demonstration for an Arid Site/Hanford	
382 - Develop Real-Time Corrosion Monitoring Techniques/SRS	
419 - Determine Salt Dissolution Kinetics/SRS	
594 - Develop Strategy and Method for Managing Interface Between Functions/TFA	
598 - Waste Chemistry/TFA	
500 - In Situ Sludge Treatment Capability Studies/Oak Ridge	1.3.1.5 Treat Heel In Place
546 - Testing of Capillary Breaks/Hanford	1.3.1.7 Stabilize Tank for Closure
547 - Getter Materials/Hanford	
578 - Long-Term Testing of Surface Barrier/Hanford	
529 - Waste Acceptance Testing/Hanford	1.3.2.1 Monitor Waste for Acceptance
540 - Contaminant Release from Waste Form/Hanford	1.3.2.2 Determine Performance of Waste Form
545 - In Situ Testing of LLW Glass Release/Hanford	
590 - Establish Waste Acceptance for Idaho Grout/TFA	
87 - Manage Disposal of Tank Farm Failed Equipment/SRS	1.3.2.3 Provide Disposal System
462 - Close LLW Storage Vaults/SRS	
482 - On-Line Monitoring Waste Retrieval Process/Oak Ridge	
546 - Testing of Capillary Breaks/Hanford	

Table 2.1. (contd)

Site Need	Problem Element
547 - Getter Materials/Hanford	1.3.2.3 Provide Disposal System (contd)
578 - Long-Term Testing of Surface Barrier/Hanford	
589 - Need for Consistent Waste Acceptance Criteria for Private Vendors/TFA	

DST	double-shell tank
DWPF	Defense Waste Processing Facility (at Savannah River Site)
HLW	high-level waste
Idaho	Idaho National Engineering Laboratory
LDUA	Light-Duty Utility Arm
NDE	nondestructive evaluation
Oak Ridge	Oak Ridge Reservation
SBW	sodium-bearing waste
SRS	Savannah River Site
SST	single-shell tank
TFA	Tanks Focus Area
WD&C	Waste Dislodging and Conveyance

Section 3 - TFA Technical Program

This section describes the assumptions and recommendations for a nationwide 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 technical strategies, and tables that summarize the problem elements of the TFA program (with their problems, solution paths, and deliverables) and the recommended program budget.

3.1 TFA Technical Program Overview

In FY95, the TFA developed the organizational and technical basis for a nationally integrated technology program. During FY96, the TFA more fully developed its understanding of DOE complex-wide tanks remediation issues, as well as the sites, users, and stakeholders. This MYPP reflects the TFA's transition from a programmatic or budged-based program to one that is more soundly needs driven.

This year's process of actually collecting site needs essentially remained the same as last year. The process is described in the *TFA FY 1996 Site Needs Assessment* (TFA 1996). However, the TFA revamped its process of constructing a technology development program from those needs. Problem elements replaced the technical elements that were used last year as the superstructure linking site needs to program formulation. The problem elements present a more compact, understandable, and process- and systems-oriented foundation. The site needs assessment (see Section 2) produced high-impact needs that were placed within the problem element structure, and together defined the TFA's objective to meet the fundamental DOE remediation objectives of reducing technical, programmatic, or Environmental Safety & Health risks and reducing the overall cost of remediation.

Programmatically, the TFA entered FY95 heavily mortgaged, with the program organized into a) "early win" tasks that had the prospect of delivery within 1 to 3 years to address immediate uncertainties in site baselines, b) "enhancements" to significantly improve remediation baselines by reducing costs and risks over the remediation life cycle, and c) "longer term/high-payoff solutions" to provide alternatives to the baseline technical approach. During the past year, the program enjoyed success in all three areas. Yet, more dramatic is the TFA's ongoing shift from a predominantly mortgaged program to one that is more responsive and flexible to site needs. The development of TFA's "right program" reflects this shift.

The "right program" concept began with the site needs assessment. The TFA examined closely all site needs submitted, developed a needs prioritization process and applied it, identified relationships between needs, and proposed technical responses to needs. With a shrinking mortgage base, the TFA was able to address site needs more broadly and deeply than before. The TFA developed and proposed an FY98 program (called the "right program") equal to what must be done to effectively, efficiently, and safely remediate tank wastes.

Essential to carrying site needs through to program development was the creation of problem elements. By describing the full range of high-level tank waste remediation subjects, the problem elements support a program that is responsive to important tank remediation needs, either because of the needs' urgency and scope to a single site or for multisite benefit. The TFA assumes that EM-30 and EM-40 programs will continue to respond to high-priority site-specific problems. Therefore, the TFA must remain cognizant of tank technology needs and activities across the complex and continue to provide data relevant to complex-wide processing requirements and conditions so that technical solutions applicable at one site will benefit others. Table 3.1 lists the problem elements of the TFA.

3.2 Strategy for Technology Development

In Table 3.1, problem elements shown in bold are those in which TFA is making investments in FY97 and beyond. Figure 3.1 illustrates relationship between these problem elements and a generic tank remediation flowsheet. This figure depicts the systems approach taken by the TFA in developing a responsive program that provides integrated technology solutions to key user problems. The figure identifies the scope of work to be conducted by the TFA or in conjunction with the TFA. Hence, work conducted through the crosscut, industry, university, other focus areas, and user programs as well as the TFA managed program is included. The TFA tasks are further identified by Technical Task Plan number for work to be conducted in FY97.

In Section 3.3.1, the technical strategy behind these investments for each of the problem elements is described. With a few notable exceptions, the general technology development strategy for the TFA is to acquire technology and prepare it for deployment in the operating environment. Preparation for deployment either involves 1) demonstration and data acquisition for the user to support decisions and flowsheet development or 2) deployment, testing, and transfer of new technology to the user for continued operation. Technology is acquired either from industry, EM-50 crosscutting programs, university programs, international programs, other focus areas, or user programs. This second situation arises when one site has successfully used a technology and with some adaptation a second site can also use the technology. TFA supports the technology adaptation and transfer in these situations. The technologies that the TFA will acquire from industry and the other EM-50 programs are listed in the appropriate problem elements in Appendix B and are identified briefly in each of the problem elements in this section. As the EM Science Program matures, the TFA will also look for technology and science developments that can be transferred.

The exceptions to this overall strategy of technology acquisition and preparation for deployment include retrieval process development, sludge processing, and HLW form and process development. Currently, EM-50 does not have crosscutting programs to address these aspects of tank remediation, because the science and technology needed for these areas is specific to tanks. Therefore, the TFA does invest in these areas to bring less mature technology concepts forward for future deployment and technology transfer. These investments are included in the description of the problem elements in Section 3.3.1.

Table 3.1. Problem Element Structure[(a)]

WBS#	Problem Element
1.0	Remediate Tanks
1.1	Store Waste
1.1.1	Extend Tank Life
1.1.1.1	**Monitor Tank Integrity**
1.1.1.2	**Avoid Tank Corrosion**
1.1.1.3	Remediate Loss of Tank Integrity
1.1.2	Ventilate Tanks
1.1.3	Characterize Waste
1.1.3.1	**Characterize Waste In Situ**
1.1.3.2	**Sample Waste**
1.1.3.3	**Analyze Waste**
1.1.4	Reduce Waste Volume
1.1.4.1	Reduce Source Streams
1.1.4.2	**Reduce Recycle Streams**
1.2	Process Waste
1.2.1	Retrieve Waste
1.2.1.1	**Deploy Equipment**
1.2.1.2	**Mobilize Bulk and Heel Wastes**
1.2.1.3	Mix Waste
1.2.1.4	Transfer Waste
1.2.1.5	**Detect and Mitigate Leaks**
1.2.1.6	**Monitor & Control Retrieval Process**
1.2.1.7	**Integrate Retrieval and Pretreatment Technology Systems**
1.2.1.8	Mobilize Heel
1.2.2	Pretreat Waste
1.2.2.1	**Calcine Waste**
1.2.2.2	Dissolve Waste
1.2.2.3	**Prepare Retrieved Waste for Transfer and Pretreatment**
1.2.2.4	**Clarify Liquid Stream**
1.2.2.5	**Remove Radionuclides**
1.2.2.6	Integrate Pretreatment and LLW Immobilization Technology Systems
1.2.2.7	**Process Sludge**
1.2.2.8	**Prepare Pretreated Waste for Immobilization**
1.2.2.9	Monitor & Control Pretreatment Process
1.2.3	Immobilize Waste
1.2.3.1	Process LLW
1.2.3.1.1	**Monitor & Control LLW Immobilization Process**
1.2.3.1.2	Prepare LLW Feed
1.2.3.1.3	**Immobilize LLW Stream**
1.2.3.1.4	Treat LLW Offgas
1.2.3.1.5	Dispose of LLW
1.2.3.2	Process HLW
1.2.3.2.1	**Monitor & Control HLW Immobilization Process**
1.2.3.2.2	**Prepare Secondary Waste from Pretreatment**
1.2.3.2.3	**Prepare Sludge Feed**
1.2.3.2.4	**Immobilize HLW Stream**
1.2.3.2.5	**Treat HLW Offgas**
1.3	Store Waste Forms and Close Tanks
1.3.1	Close Tanks
1.3.1.1	Monitor Tank
1.3.1.2	Characterize Heels
1.3.1.3	**Define Closure Criteria**
1.3.1.4	Treat Supernate In Place
1.3.1.5	Treat Heel in Place
1.3.1.6	Detect Leaks
1.3.1.7	**Stabilize Tank for Closure**
1.3.1.8	Monitor Site
1.3.2	Dispose of LLW
1.3.2.1	Monitor Waste for Acceptance
1.3.2.2	Determine Performance of Waste Form
1.3.2.3	Provide Disposal System
1.3.3	Store and Dispose HLW
1.3.3.1	Provide Interim Storage HLW
1.3.3.2	Provide Shipping Facilities

(a) Bold problem elements are those in which TFA is making investments in FY97 and beyond.

The problem elements were developed around key needs identified by one or more user sites for which either large cost reductions or a higher probability for successfully meeting site remediation goals could be achieved. The level and type of technology development investment within each of the problem elements reflects the general approach that TFA is taking. Namely, the TFA investments support current DOE strategy for remediating tanks. This strategy includes waste retrieval and processing to produce low-level waste (LLW) forms for disposal onsite and HLW forms for disposal in a repository. This tank remediation strategy is the basis for Federal Facility Compliance Agreements at the four tank sites. However, the technology development investments are also applicable to alternative approaches and strategies that could be selected by DOE and site stakeholders in the future. The relationship between the technical development investments supporting the current strategy and potential alternative strategies for tank remediation is discussed in Section 3.3.2.

3.3 Technical Strategies by Problem Element

Problem Element 1.1.1 Extend Tank Life. Regardless of the remediation strategy eventually selected by each site, the tank life for most of the tanks will be exceeded by the time remediation is complete. Therefore, methods to slow the rate of corrosion that leads to loss of tank integrity could significantly reduce the risk of releases. Moreover, there are already tanks known or suspected to leak for which methods to determine the extent and location of leakage will provide a better basis for selecting monitoring, retrieval, and closure strategies. Therefore, the TFA is investing in this problem area. Specifically, investments are being made in tools for monitoring tank integrity (Problem Element 1.1.1.1) and methods to avoid corrosion (Problem Element 1.1.1.2).

The technical strategy for developing corrosion monitoring tools encompasses both monitoring devices to determine corrosion rates and in-tank inspection tools to identify and locate potential points for leakage before beginning retrieval operations. Measuring corrosion rates allows operators to forecast potential loss of tank integrity and to take preventive measures in time. The baseline technology is the use of coupons (i.e., small samples) to measure corrosion rates. This method requires recovery of the coupons from tank to make corrosion rate measurements. Understanding where leakage may occur allows operations to select appropriate retrieval tools and define mining strategies that reduce the potential for releases. The baseline technology is the use of cameras that are lowered through a riser with lights to visually inspect. This method is limited to visual inspection. Specific technologies supported by TFA to replace the baseline techniques include

- electrochemical noise corrosion monitor, which is deployed through a tank riser, for use at SRS

- nondestructive examination end effector to be deployed by the Light-Duty Utility Arm (LDUA) at Idaho Chemical Processing Plant.

The technical strategy for developing methods to avoid corrosion includes both near- and longer-term approaches. In the near term, the strategy is to adapt commercial monitors to better control the current method for avoiding corrosion, the addition of inhibitor water.

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Inhibitor water is added to tank wastes to maintain the ratios of $NO_3/NO_2/OH$ which reduce corrosion rates. A monitor to detect the ratio of $NO_3/NO_2/OH$ in tank liquids can be used to control the volume of inhibitor water added to tanks during either waste storage or in-tank processing. This water increases the overall volume of HLW and LLW that.must be processed and disposed. Thus, reducing inhibitor water volume reduces waste processing and disposal costs. The first deployment of this monitor, which will which be acquired from industry, is scheduled for SRS tanks.

The longer-term strategy for avoiding corrosion in tanks includes identification and demonstration of passive systems to reduce corrosion rates. Recent lessons learned in other industries will be evaluated to develop and provide alternative methods for avoiding tank corrosion without adding excess water or chemicals that would add to the volume of waste requiring processing and disposal. These systems could be deployed at Hanford and SRS once tailored to these sites' operational requirements.

Problem Element 1.1.3 Characterize Waste. Waste characterization is required for safe storage of waste as well as designing effective retrieval, pretreatment, and immobilization systems to process waste. Moreover, waste characterization, along with tank integrity determination discussed in the previous section, helps stakeholders define closure requirements for tanks, including the degree to which tank waste must be retrieved or treated in place. The TFA is investing in tools and methods to characterize waste in situ (Problem Element 1.1.3.1), sample waste (Problem Element 1.1.3.2), and analyze waste (Problem Element 1.1.3.3).

The technical strategy for developing in situ waste characterization technology is to adapt analytical methods designed for use in hot cells for deployment in systems such as a cone penetrometer or LDUA. The cone penetrometer deployment platform has the advantage of providing sludge rheology data while also obtaining moisture and speciation data. The LDUA deployment platform has.the advantage of collecting and analyzing samples from the vapor, liquid, or soft sludge phases at off-riser locations. The baseline technology for waste characterization is supernate sampling devices or coring techniques to remove a sludge core followed by full analysis of core samples at an analytical chemistry laboratory. A reduction in cost and schedule can be achieved with in situ characterization techniques. Specific technologies supported by TFA for in situ characterization to replace or augment the coring/analysis approach include

- incorporation of a Raman probe into a 35-ton cone penetrometer for use at Hanford
- development of a minilab end effector for the LDUA to measure safety and retrieval process related characteristics of tanks at Idaho Chemical Processing Plant

The technical strategy for developing waste sampling technology is to extend the use of currently available sampling devices used for below-riser operations to off-riser operations and to adapt commercially available systems for use in a radioactive environment. Specific technologies or activities supported by TFA include

- use of gripper end effector for LDUA to move currently used sampling devices to off-riser locations in Tanks 104-AX and 106-C at Hanford (part of Hanford Tanks Initiative)

- evaluation of an as-yet-to-be-selected commercial device that is simpler to deploy than the LDUA and can be used for off-riser sampling in Hanford tanks (through Characterization, Monitoring, and Sensors Technology Crosscutting Program)

- simple "flop-arm" samplers for use in Tanks 19 and 20 at SRS.

The technical strategy for developing waste analysis technology is to provide scanning techniques that allow rapid determination of whether or not a core sample must undergo full analysis. The window of opportunity for deploying and using these techniques at Hanford to meet the site characterization activities is between FY96 and FY00. Therefore, the technologies selected are either commercially available and adapted to this application or near final development stages so that deployment can be accelerated to meet near-term schedules for transferring technology to the users. In FY96, a near infrared scanning device to detect moisture was transferred to Hanford. In FY97, transfer of the LA/MS for elemental and radioisotopic analysis will be completed. After FY97, the TFA will support-through the Robotics Program-automation of the scanning devices if usage warrants.

Problem Element 1.1.4.2 Reduce Recycle Streams. Tank farms are still receiving wastes even though many major mission operations have ceased at most of the sites. Some of these wastes are or will be generated from decontamination and decommissioning (D&D) operations or from tank-to-tank transfer to solve various types of waste storage problems or from tank waste processing operations. An example of the latter situation is the recycle stream from the Defense Waste Processing Facility at SRS. Removal of dilute concentrations of cesium, solids, and mercury from this stream would allow it to be processed through the site's water treatment plants for release through a National Pollutant Discharge Elimination System permitted outfall rather than being recycled to the tank farms for reprocessing through the plant. There is no baseline technology for treating this stream; it is simply added back to the tanks for storage and eventual reprocessing through the Defense Waste Processing Facility.

The technical strategy for addressing this problem is to assemble a treatment train of commercially available technologies to meet the waste acceptance criteria for the SRS's liquid effluent treatment plant. The TFA will evaluate the use of a compact processing unit concept to avoid large capital expenditures on new facilities. The TFA will also evaluate options for reducing mercury concentration in this stream, which would reduce the complexity of the treatment train. (See Problem Element 1.2.3.2.5 Treat HLW Offgas.)

Problem Element 1.2.1.1 Deploy Equipment. There are many in-tank activities required to continue safe waste storage operations and to begin tank remediation and closure actions. There were 18 different needs identified by the users in FY96 alone. Responding to these needs is complicated by the fact that activities range from use in the tank annuli, to the tank head space, and to the waste both below and at off-riser locations. Furthermore, the configuration of the tank internals can vary significantly from complicated in-tank evaporator coils to relatively open space, but with a limited number of available risers through which to insert or remove tools or monitors. In some applications, precise placement is required whereas in other applications long reach is required. In-tank activities range from insertion of devices, to in-tank or in-annuli operations such as inspection, characterization, retrieval, or treatment, to safe removal and decontamination of mired equipment. The most typical approach used at the sites today is limited to manual, below riser insertion.

The technical strategy for development of deployment systems for various in-tank operations is to complete deployments of newly available technology, to identify simpler systems for future deployment, and to provide tools to detect obstructions during deployment. The newly available technologies include the LDUA developed through EM-50 and the Houdini vehicle system developed by industry and procured through industry programs. First deployments of the LDUA systems will be completed at Hanford and ORR in FY96 and FY97, respectively. INEL's first deployment is tentatively scheduled for FY98. In addition, specific missions defined by the user for the closure of tanks at Hanford (i.e., Hanford Tanks Initiative) will require some adaptation of the baseline LDUA control system and adaptation of end effectors for new duties in FY97. Future development of any end effectors or updates to the LDUA system will be pursued as user missions become better defined and user requests for adaptation to the baseline system are made.

First deployment of a vehicle-based system is scheduled for early FY97 at ORR in the gunite tanks. This vehicle is being provided by the Industry and Robotics Crosscut Programs. The Robotics Program is also providing a characterization end effector; and the TFA is providing a retrieval end effector, for the vehicle or LDUA deployment platforms (see Problem Element 1.2.1.2). This vehicle is anticipated to be used in tanks without cooling coils on the bottom with either relatively shallow soft sludges or with hard sludges. Moreover, a combination of an arm and a vehicle may prove most effective.

New deployment approaches or systems will be provided after a systematic evaluation of all the in-tank operations planned between FY96 and FY00 across the complex. This evaluation will include definition with the user of the performance requirements to meet these needs. Working with the Robotics and Industry Programs, the TFA will adapt existing systems or develop new systems as needed that are more sophisticated than the current below-riser operations and less complex that the LDUA system. An example of a possible early development activity in this area is the addition of a control system (from the Robotics Program) to the borehole miner technology (identified and used through the TFA) used to break up heels in tanks for better characterization or for retrieval of that heel. The borehole miner is commercially available but is manually operated. With the addition of a simple control system, more sophisticated mining strategies could be implemented, enhancing the value of this relatively simple device in heel breakup. A possible early application could be Tank 19 at SRS where a zeolite heel must be broken up to obtain adequate characterization data to determine tank closure requirements.

Finally, commercial sensors for in-tank survey of metal obstructions in sludge and in the cross-sectional area under the tank riser will be obtained for demonstration through the Characterization, Monitoring, and Sensors Technology Program. This technology will help operators avoid collisions during insertion of mixing pumps, analytical trees, or other in-tank hardware.

Problem Element 1.2.1.2 Mobilize Bulk and Heel Waste. Bulk tank wastes are mobilized and mixed before removal from the tanks. These wastes are either supernates with sludge that must be resuspended before transfer or saltcake that must be dissolved and transferred. The baseline technologies for bulk waste retrieval at Hanford, SRS, and INEL are mixer pumps coupled with transfer jets. The mixer pumps, however, are expensive and have two operating problems that, if solved, would significantly reduce cost and improve efficiency of operation. First, leaking seals introduce water into the tank waste, increasing overall waste volumes that must be processed. Moreover, leaking seals cause out-of-specification feed to be delivered to the process. Second, improving of the effective mixing radius of the mixer pumps would reduce the number of pumps required and hence, the capital, operating, and maintenance costs for these expensive pumps.

After the bulk waste has been removed, many tanks have a heel remaining. In some cases, the heel is soft, but could not be removed due to depth limitations of the transfer jets. In other cases, the heels are very hard and difficult to breakup and remove. The amount of material that can be left in a tank is directly related to the closure criteria. The baseline technology for heel removal is past-practice sluicing in which water is sprayed at the surface of the heel at low pressures. This practice introduces large volumes of water that must be processed and for tanks that are known or suspected to leak, introduces a higher risk for release of tank waste during retrieval.

The technical strategy for bulk waste removal is directed at both enhancements and alternatives to mixer pumps. The enhancement activity focuses on TFA supporting users at Hanford and SRS in testing and analyzing test data on the advanced mixer pump(s) which was designed and procured in FY96. In parallel, alternative mixing technologies are being readied for demonstration to compare against the baseline performance of the existing and advanced mixer pumps. These alternatives include the following:

- pulsed air systems developed by industry (i.e., Pulsair) to suspend solids before transfer

- fluidic systems developed and used in the United Kingdom (through the International Program/ AEA Technologies) to suspend and transfer solids at SRS and ORR's Bethel Valley Evaporator Storage Tanks

- modified density gradient techniques coupled with low flow rate pumps for saltcake dissolution and removal from Tank 41 at the SRS (low flowrate pumps from International Program/AEA Technologies)

- Russian retrieval technology (International Programs/Minatom).

The technical strategy for heel retrieval is directed at both confined sluicing and enhanced or alternative sluicing devices and processes. Confined sluicing is designed for heel retrieval from tanks in which only low volumes of water can be safely introduced (i.e., leaking or potentially leaking tanks) and both medium or high pressures can be used. These devices are typically designed for deployment with either arms or vehicles. Two of these technologies supported by the TFA are

- Confined Sluicing End Effector (CSEE) (from Waterjet Technologies Inc., designed by University of Missouri - Rolla) for use in ORR gunite tanks for relatively soft sludge heel removal and INEL tanks at Idaho Chemical Processing Plant for heel retrieval around coils at tank bottom

- Light-Weight Scarifier (from Waterjet Technologies Inc.) for hard sludge heel removal.

Enhancements and alternatives to past-practice sluicing are designed for heel breakup for characterization or removal from tanks in which larger volumes of water can be safely added at medium pressures. The approach is to develop mining strategies for these systems, improve nozzle designs currently used by industry to meet performance requirements, and to demonstrate simple systems that are rapid and inexpensive to deploy.

An alternative sluicing technology supported by TFA is the borehole miner (from Waterjet Technologies Inc.) which will first be used on Tank 19 at SRS to breakup a zeolite heel for characterization to support tank closure.

An enhanced sluicing systems supported by TFA includes enhanced nozzle and sweep design of current system for Hanford.

One of the areas in which TFA supports retrieval technology development and demonstration is simulant development and cataloging. Simulants are needed to evaluate alternatives and develop new approaches because large, undisturbed samples cannot be taken from the tanks. Maintaining pedigreed simulants allows 1) useful comparisons between alternative retrieval methodologies and 2) development of meaningful mining strategies.

Problem Element 1.2.1.5 Detect and Mitigate Leaks. There are approximately 90 tanks known or suspected to have leaked in the EM system to date. Before the remediation of tanks is completed across the complex, the life of most tanks will be exceeded. The TFA is investing in methods to avoid leaks and extend tank life as discussed under Problem Element 1.1.1. Nonetheless, for those tanks that have already leaked, technologies for tank waste removal with minimal environmental impact is needed.

The technical strategy for leak detection and mitigation is to provide both retrieval methods that avoid leakage by controlling and minimizing water addition as described in Problem Element 1.2.1.2 and leak detection devices that can provide rapid data output to guide retrieval operations. The baseline technology for leak detection measures liquid level of the waste in tanks during retrieval. Liquid level can be affected by the retrieval operation and is only accurate to tens of thousands (10,000s) of gallons of leaked waste. Moreover, the location of the leaks cannot be determined with the current baseline technology. The TFA is supporting deployment of Electrical Resistance Tomography which can be rapidly and inexpensively deployed with a cone penetrometer. Electrical Resistance Tomography is a Characterization, Monitoring, and Sensors Technology-developed technology that can detect leaks to hundreds of gallons and identify the location of the leaks. First deployment is scheduled for the Hanford Site.

The challenge for deployment and use of this technology is development of leak detection requirements by the user with stakeholder input and definition by this same group of options for follow-on actions if a leak is detected during operations.

A secondary technical strategy for leak mitigation is directed at repairing or containing leaks. This strategy will be explored if the primary approach of leak avoidance and detection is unsatisfactory to the users and stakeholders and there is a high enough demand for these techniques. Hence, startup of a task in this area will be delayed until the performance requirements are better defined and a cost-benefit analysis can be completed. At that time, the approach is to first explore experience of non-nuclear industries.

Problem Element 1.2.1.6 Monitor and Control Retrieval Process. During waste retrieval operations, slurries are transferred from the tanks through transfer lines to another storage tank or a process tank in preparation for pretreatment activities. Transfer line pluggage is a concern for operations. Moreover, particle size and weight percent solids impact the efficiency of the downstream pretreatment operations. Therefore, the physical properties of the retrieved waste must meet certain operational requirements for retrieval and pretreatment operations to be successful. These physical properties include flow rate, viscosity, weight percent solids, and particle size distribution. Monitors that can provide these data are needed. In recent tests at Hanford, it was shown that currently available monitors could measure flow rate and viscosity (at least qualitatively); however, weight percent solid and particle size distribution could not be measured with currently available monitors. Therefore, the baseline technique is to sample slurried waste before transfer and conduct out-of-tank analysis.

The technical strategy for retrieval process monitoring is both to improve sampling techniques which enhance the current baseline technology and to provide alternative on-line slurry monitoring. To improve sampling, simple methods that remove a homogenous and representative aliquot of slurry from a transfer line must be tested. To provide alternatives, on-line slurry monitors that are able to provide real-time, quantitative data on viscosity, weight percent solids, and particle size distribution must be developed. The following activities are supported by TFA:

- demonstration of a sampling device initially designed for use at SRS (International Program/ AEA Technologies)

- preparation and downselection of several types of on-line slurry monitors for downselect testing (joint Characterization, Monitoring, and Sensors Technology and TFA)

- demonstration of on-line monitor(s) during retrieval of Bethel Valley Evaporator Storage Tanks at ORR and during Tank 106-C heel removal at Hanford.

Problem Element 1.2.1.7 Integrate Retrieval and Pretreatment Technology Systems. One of the TFA's programmatic goals is to deliver integrated technology systems to meet key user problems. Meeting this goal requires that the TFA systematically evaluate impacts of technology selection and development between functional areas such as retrieval and pretreatment. For example, the selection of a retrieval technology by a user is based on the waste type, the degree to which the tank waste must be removed to meet tank closure requirements, and retrieval performance requirements such as removal rate, deployability, maintainability, and cost. The retrieval system, however, should also take into consideration the downstream pretreatment process requirements such as particle size distribution and weight percent solids. These properties affect the rate at which solids can be removed during solid-liquid separations and the efficiency of leaching and washing sludges. The TFA strives to identify data and technology gaps between retrieval and pretreatment that are needed for these types of considerations.

The technical strategy taken by the TFA to provide databases and simple decision analysis tools for retrieval and pretreatment technologies that can be used for a systematic evaluation of options. The databases would include available performance and engineering data for technologies currently in the sites' baselines, for technologies being developed and tested through EM-50 or user programs, and for technologies used commercially (i.e., mining and oil industry for retrieval tools and mining and chemical industry for pretreatment tools). Moreover, data from international experience (e.g., United Kingdom and Russia) will also be included. These tools will be used by the TFA to identify gaps in data and technology for program planning and will support transfer of new technologies to users by providing data needed to evaluate retrieval and pretreatment systems in an integrated manner.

Problem Element 1.2.2.1 Calcine Waste. Calcining blended acidic wastes for interim storage has been the baseline technology for INEL's tank waste stored at the Idaho Chemical Processing Plant. The remaining wastes, however, are higher in sodium and the waste stream with which they have been blended in the past to reduce the sodium concentration is no longer available. Therefore, the current calcination process must be modified so that a product that meets performance requirements is produced.

The technical strategy for calcining wastes is to provide an integrated technology solution that contains both an improved process and the corresponding process monitor. The process will incorporate either chemical destruction of the nitrates or higher calcination temperatures. The user program will pursue the higher temperature option, while TFA will evaluate the sugar additive method of denitration. The monitor will adapt technology developed through Diagnostic Instrument Analytical Laboratory and Characterization, Monitoring, and Sensors Technology Program to monitor hydrocarbons and elemental species such as sodium, aluminum, iron, calcium, fluorine, and potassium, and Resource Conservation and Recovery Act metals to control process upsets and identify out-of-specification combination of compounds.

Problem Element 1.2.2.3 Prepare Retrieved Waste for Transfer and Pretreatment. Physical and chemical properties of tank wastes impact the efficiency of retrieval, and pretreatment. The physical properties include viscosity, weight percent solids, and particle size distribution. These properties can be affected by the chemical characteristics of the waste including speciation, pH, ionic strength, and the presence of a separable-phase organic layer. Various chemical combinations can lead to gelation which will adversely impact fluid transfer (i.e., plug lines, and settle-decant rates). Ionic strength and pH can affect particle size and aggregation which can lead to the formation of colloidal material which can adversely affect settle-decant as well as downstream supernate and sludge processing. Separable-phase organic compounds may cause the partitioning of some constituents that can impact radionuclide removal efficiencies. A better understanding of the effects of these properties on both transfer and pretreatment process efficiency is needed to ensure selection of appropriate performance requirements during retrieval operations.

The technical strategy is to develop an understanding of impacts of chemical and physical conditions of the waste on rheology and process chemistry. Particular emphasis will be placed on dry, hardened sludges and combinations of saltcake and sludges. Specifically, conditions which affect bulk transport properties will be determined and translated to process requirements for retrieved waste. These requirements may in turn lead to the need for

- in-tank waste tools such as grinders to control particle size
- dissolution conditions that avoid tank corrosion while resulting in waste streams that can be efficiently processed
- recommendations on blending to improve downstream process efficiency
- organic destruction requirements.

The TFA will support the following activities to better understand the operating requirements:

- evaluation of the affects of physical and chemical conditions on slurry rheology for Hanford, ORR, and SRS waste types at Florida International University
- evaluation of a sludge storage model provided by the Russians through Minatom to obtain insights into sludge aging
- development of retrieval waste process requirements with users at Hanford, ORR, and SRS
- demonstration of in-tank or in-line grinders for adjustment of the physical properties of retrieved waste before transfer, especially cross-site transfer of wastes (Industry Programs)
- in conjunction with sludge processing work conducted under Problem Element 1.2.2.7 Process Sludge, development of recommendations on blending of tank wastes or sludges and supernates to avoid adverse transfer or pretreatment processing conditions such as gelation
- in conjunction with sludge processing work conducted under Problem Element 1.2.2.7 Process Sludge, and new work in Efficient Separations and Processing directed at slurry processing, development of recommendations on retrieval process water composition requirements that avoid adverse process conditions.

As the EM science program matures, the TFA anticipates that scientific studies conducted through that program will also have relevance to these issues.

Problem Element 1.2.2.4 Clarify Liquid Streams. After retrieval, the wastes must be separated into supernate and sludge streams to reduce the volume of material going to the vitrification process.

The baseline technology for this solid-liquid separation is settle-decant. The efficiency and rate of the settle-decant operations, however, does not appear adequate for many of the waste streams. For example, carryover of small particulates in the Hanford supernates may lead to LLW that exceeds the waste acceptance criteria for TRU and strontium which tend to associate with these fine solids. Moreover, small particulates may clog ion exchange columns used to remove cesium and technetium from supernates to meet LLW acceptance criteria. Therefore, methods to ensure clarification of liquids is needed to meet process requirements for pretreatment and LLW immobilization.

The technical strategy for clarification of liquids is three-fold: complete collection of data on base-line at Hanford, demonstrate techniques to enhance the baseline, and provide process flexibility through compact processing units. The baseline process for Hanford is settle-decant without active filtration. Data for settle-decant operations are being developed on actual wastes at Hanford through the user program with some technical support from TFA. Enhancements to settle-decant include active filtration to remove fine particulates from the supernate. Crossflow filtration, which is commercially available, has been selected as the filtration system for demonstration based on experience gained at SRS over the last decade. Active filtration is being demonstrated on actual wastes at Hanford, ORR, and INEL.

- **Hanford** - evaluate crossflow filtration on a range of Hanford waste types which differ in physical properties from those at SRS and ORR (hot cell scale unit being used)

- **INEL** - obtain performance data on crossflow filtration at to remove undissolved solids from acid waste and to evaluate regeneration with back pulse or non-acid wash (hot cell scale unit being used)

- **ORR** - obtain operational experience on a larger scale system by preparing gunite tank wastes for cross-site transfer.

Enhancements to the current crossflow filtration technology are also being supported by TFA and include

- evaluation of Russian alternative filter units for use in crossflow filtration systems (International Program/Minatom)

- identification of alternative filter units for crossflow filtration that avoid generation of waste cartridges (Industry Programs).

The third element of the TFA technical strategy is the development of compact processing units for active filtration. Compact processing units have the advantage of being located near the point of usage and can be scaled to handle smaller capacities to provide flexibility in pretreatment operations. Experience from international work will be used as much as possible (i.e., AEA Technologies).

Problem Element 1.2.2.5 Remove Radionuclides. Supernate processing is used by Hanford, INEL, and SRS to reduce the levels of cesium, technetium, strontium, or TRU to meet LLW disposal requirements on-site. These requirements are established through performance assessment of the

LLW disposal facility. For ORR, cesium removal is required to meet waste acceptance criteria established by the Nevada Test Site for LLW. The baseline technology at SRS is in-tank precipitation with tetraphenylborate. A cost-effective alternative to tetraphenylborate, especially for high phosphate streams, is being explored. The baseline technology at INEL is expected to be solvent extraction; however, these processes have not been demonstrated on actual INEL wastes. The baseline technology for Hanford is still being determined, but ion exchange is most typically used for flowsheet development. The baseline technology for ORR is ion exchange.

In general, the technical strategy for radionuclide removal is built around developing and demonstrating processes and process equipment using actual wastes for collection of performance and engineering data. The TFA is acquiring process technology from the Efficient Separations and Processing Program and the International Program using both AEA Technologies and Russian technology provided through Minatom. In addition, the TFA is using commercially available equipment for demonstration of these processes configured where possible as compact processing units and transferring these units to the user programs at the completion of a demonstration. Finally, in keeping with the TFA's programmatic goal of providing integrated technology solutions, the Characterization, Monitoring, and Sensors Technology Program will being developing process monitors as part of the process control system and the TFA will ask the Robotics Program to assist in development of remote operating systems as needed.

The specific technical strategy for cesium removal from alkaline wastes includes conducting flow studies using new sorbents on a single waste type (i.e., Melton Valley Storage Tank wastes at ORR) to evaluate sorbent performance. Results from these flow studies are used to identify the most promising sorbents which are then evaluated on a broader set of waste types at Hanford and SRS. In addition, processing systems are being demonstrated on a large enough scale to obtain operating data. The following technology activities are supported by the TFA for cesium removal in accordance with this strategy:

- development and testing of new sorbents through the Efficient Separations and Processing
- flow studies on Hanford waste types to evaluate selected sorbents, based on Efficient Separations and Processing results from new sorbent testing
- demonstration of a compact processing unit with Efficient Separations and Processing-developed crystalline silicotitanate to process 94,635,29 L (25,000 gal) of Melton Valley Storage Tank waste (see Problem Element 1.2.3.2.2 for description of strategy for handling cesium-loaded crystalline silicotitanate as part of the integrated technology solution)
- evaluation of crystalline silicotitanate in an in-tank precipitation process for SRS through Efficient Separations and Processing in FY97, transferring to TFA in later years where out-of-tank options will also be evaluated using compact processing unit concept
- development of process monitor to detect and measure cesium in process effluents through the Characterization, Monitoring, and Sensors Technology Program

- development of remote systems to change out ion-exchange columns from compact processing units through the Robotics Program.

The technical strategy for cesium removal from acidic wastes is to provide performance and engineering data to INEL users on solvent extraction processes to confirm their baseline process assumptions. The following activities are planned:

- development of a cesium solvent extraction process through the Efficient Separations and Processing Program

- demonstration of this process on actual waste through TFA.

The technical strategy for technetium removal from Hanford wastes starts with collection of baseline process information on commercial anion exchangers and then extends to waste types and process alternatives for which these anion exchangers cannot be used. The following technology activities are supported by TFA for technetium removal in order of most mature to least mature technology reflecting the technical strategy:

- flow studies on organic-free Hanford wastes using commercially available anion-exchange resins for removal of technetium in pertechnetate form; data provides a baseline for comparison of alternatives

- evaluation of chemical or thermal methods to convert non-pertechnetate species found in organic-bearing Hanford wastes to pertechnetate for removal by commercially available anion-exchange resins

- engineering development and demonstration on Hanford wastes of an electrochemical method for technetium removal used in the United Kingdom (International Program/AEA Technologies)

- evaluation of a Russian technology using an inorganic porous matrix for capture and interim storage of technetium and other species of interest (International Program/Minatom)

- development of alternative approaches for removal of non-pertechnetate species through Efficient Separations and Processing; additional technetium speciation data will be obtained as needed for this development

- development of process monitor to detect and measure technetium in process effluents through the Characterization, Monitoring, and Sensors Technology Program.

The technical strategy for TRU and strontium removal from acidic waste is to provide performance and engineering data to INEL users on solvent extraction processes to confirm their baseline process assumptions. The following activities are supported by TFA for removal of TRU and strontium from acidic wastes demonstration of TRU and strontium solvent extraction processes at the Idaho Chemical Processing Plant.

The technical strategy to remove strontium and TRU from alkaline wastes differs for different waste types at Hanford. For organic-free wastes, active filtration to remove particulates with which these species associate is being developed (see Problem Element 1.2.2.4 Clarify Liquid for further description). For organic-bearing wastes with complex TRU and strontium, destruction of the organic compounds in the supernate is being evaluated through the Industry and the International (AEA Technologies) Programs.

Problem Element 1.2.2.7 Process Sludge. After solid-liquid separation, the sludge is processed to remove excess chemical species that either increase the volume of HLW or adversely impact the performance of the HLW form. Because there is a high cost associated with the number of glass logs produced, improvements in sludge processing that lead to a reduction in glass logs has a significant potential for cost reduction during waste processing. Sludge chemistry is complex and users prefer sludge washing and leaching tests be conducted on actual wastes from their tanks to develop flowsheets and process requirements. The baseline technology consists of washing and late washing steps at SRS; these operations are conducted in tanks in batch operations. Improvements in equipment, such as continuous washing that improves settling characteristics of the washed sludges, could reduce cost at SRS. Sludge process requirements are not yet defined at ORR, although some of the TFA work has been conducted historically on Melton Valley Storage Tank sludges giving the site some data to assist in setting requirements in the future. INEL has little sludge given the acidic conditions, hence sludge washing is not an issue for that site. Hanford is developing the baseline process assumptions at this time.

The technical strategy for processing sludge includes process chemistry for Hanford, process equipment development for SRS and Hanford, and process monitors for process control. The process chemistry work is directed predominantly at the completion of the Hanford baseline and enhancements or alternatives to that baseline that could significantly reduce cost. The baseline work (referred to as enhanced sludge washing) is being carried out in a prescribed manner for a broad range of Hanford waste types. The temperature and number of caustic wash steps along with the analytical requirements for the residual sludge and wash solutions are set by the users. Consequently, these tests provide the user with the ability to compare results for many waste types and allow them to confirm or amend assumptions about the Hanford flowsheet. These results are reported annually to the Washington State Department of Ecology and are scheduled for completion in FY97. Furthermore, these results establish baseline data against which enhancements and alternatives to sludge processing can be compared.

The enhancements to this baseline process chemistry include altering the range of temperature and pH of the washing solutions. This work is conducted on the same sets of samples that were used to obtain baseline process data for direct comparison of the baseline and enhanced methods. Conditions that lead to improved removal of important constituents during the washing process or to the formation of gels that are detrimental to sludge processing efficiency are identified. The alternatives to the baseline process chemistry include selective leaching of critical species such as chromium, phosphorus, and aluminum from sludges using various leaching solutions and conditions.

The process equipment under evaluation for the SRS site makes use of experience from the mining industry. The Colorado School of Mines is helping the TFA evaluate the technical feasibility of a countercurrent decant system for use in washing SRS sludges. If successful, this process will also improve the rate and efficiency of the solid-liquid separation that must occur at the end of this wash cycle. The TFA will also support evaluation of batch and continuous sludge washing and leaching equipment to be used at Hanford. This equipment will be identified through the Industry Program.

The process monitors are being developed through the Characterization, Monitoring, and Sensors Technology Program and will be directed at detecting of sodium, aluminum, phosphorus, sulfur, and chromium. These monitors will adjust feed streams to the melters.

Problem Element 1.2.2.8 Prepare Pretreated Waste for Immobilization. Pretreated alkaline supernate and sludge are sent to LLW and HLW immobilization processes, respectively. The baseline immobilization process for LLW at SRS and ORR is grout. The baseline process is still being established at Hanford. The supernate in these alkaline wastes contains large volumes of sodium nitrate. Nitrate concentration impacts the volume of LLW, because it is one of the chemical species driving waste form performance requirements. The sodium nitrate can be converted electrochemically to sodium hydroxide. In this process, nitrates are destroyed and recovered sodium hydroxide can be reused in the retrieval and sludge washing process steps. Cost benefit can be achieved due to the reduced volume of grouted waste and the concurrent recovery of sodium hydroxide.

The baseline immobilization process for high-level alkaline waste is vitrification at Hanford and SRS. After sludge washing, settle-decant leaves a higher than necessary water content in the sludge stream sent to feed preparation for vitrification. A reduction in this water content could reduce heat load requirements in the melter, increasing efficiency and reducing cost for operation.

The technical strategy to address these problems is to evaluate the options for further pretreating supernates and sludges to reduce costs associated with waste immobilization. The technologies being supported by TFA to accomplish this strategy are

- salt splitting and membrane separation for caustic recovery jointly supported by Efficient Separations and Processing and TFA for use at SRS and Hanford; commercial equipment will be explored through the Industry Program

- commercially available equipment for sludge conditioning to reduce water loads to melters for SRS and Hanford.

Problem Element 1.2.3.1.1 Monitor and Control LLW Immobilization Process. Product quality assurance is a necessary step in LLW immobilization processes whether grout- or glass-based processes are selected. If these processes are privatized, the DOE must be assured that the products received from the vendor process meet site disposal specifications.

The technical strategy is to work with users at the sites to define the quality assurance needs and then to evaluate the process monitoring requirements and the standard testing requirements to ensure tools and methods are available to meet DOE schedules for privatization.

Problem Element 1.2.3.1.3 Immobilize LLW Stream. The current baseline for LLW immobilization at SRS, ORR, and INEL is grouting. The baseline for Hanford is being established based on performance requirements set forth in the privatization call for proposals. Glass waste forms are being considered for Hanford and for M Area sludges at SRS. A sound basis for selecting LLW waste forms and the data needed to make this selection would help DOE evaluate privatization proposals and would provide stakeholders with better information for considering waste form options.

The technical strategy is to demonstrate a decision methodology and carry out side-by-side grout and glass processes to obtain data for use in a comparison of the two processes and resulting waste forms. The decision methodology that will be demonstrated has been used in the United Kingdom by AEA Technologies and will be adapted to meet U.S. regulatory and stakeholder requirements through the International Program. Input to these requirements will be gathered from users at multiple sites. A vitrification and a grout process for a LLW stream at ORR will be designed and operated. Existing melter technology will be used for the vitrification process; the grout processing will be conducted by AEA Technologies through the International Program.

Problem Element 1.2.3.1.4 Treat LLW Offgas. During vitrification of either LLW or HLW, offgases are generated that must be treated. To design treatment methods, the partitioning of radionuclides and chemical species at the cold cap surface must be determined. Understanding the partitioning helps users better define the potential offgas problems as well as to predict the glass composition. Offgas species of concern include both LLW and HLW vitrification include cesium, technetium, and mercury. In LLW vitrification, large quantities of NOx must handled along with lesser quantities of fluorides and chlorides. The baseline technology is water scrubbing which produces a large secondary waste stream that is recycled to the tanks and must be reprocessed at a high cost. (See Problem Element 1.1.4.2 Reduce Recycle Streams.)

The technical strategy for offgas treatment includes development of predictive models to forecast the partitioning of species between the offgas and the melt, and demonstration of treatment options. The cold cap thermodynamic model task will be funded by the TFA and the SRS user program. Results will be used to set feed requirements to vitrification processes at SRS and Hanford so that offgas problems are reduced. As a secondary benefit, the resulting feed requirements will better establish the performance requirements for upstream pretreatment and feed preparation processes described in Problem Elements 1.2.2.5 Remove Radionuclides, 1.2.2.7 Process Sludge, and 1.2.2.8 Prepare Pretreated Waste for Immobilization, allowing the TFA to deliver an integrated technology solution to these user problems.

Demonstration of treatment technologies will first be directed at NOx treatment during LLW vitrification. The work will be conducted initially within the Mixed Waste Focus Area and will be directed at use of a Russian selective catalytic reduction catalyst for NOx. The Mixed Waste Focus Area will also be evaluating a regenerable gold-impregnated, mercury-amalgamating filter to separate mercury species without scrubbing. This system could benefit the SRS where mercury-containing wastes result in releases to the offgas. The stream from the offgas scrubber comprises part of the Defense Waste Processing Facility recycle stream that is sent back to the tank farm. (See Problem Element 1.1.4.2 Reduce Recycle Streams for discussion of the recycle stream treatment needs.) Reduction of mercury in the offgas scrubber stream could result in a simplified method for treating the DWPF recycle stream. The TFA will evaluate this option as part of an integrated technology solution to the user problem identified in Problem Element 1.1.4.2.

Problem Element 1.2.3.1.5 Dispose of LLW. LLW forms are disposed of onsite at the SRS and are scheduled for on-site disposal at Hanford and INEL. The baseline technology for disposal units at SRS is concrete vaults. Currently, no credit is taken for the concrete vault system with respect to release rates from grouted wastes. The baseline technology for disposal units at INEL and Hanford is being established; it is expected to be a type of vault. The design will depend upon the LLW form provided by private vendors and requirements established by performance assessments.

The technical strategy is to use new technology in the commercial sector to provide advanced disposal concept options for the SRS and Hanford. The identification and evaluation of these concepts will be initiated through industry programs. One concept that will be considered is improving the concrete vaults so that the vault can be considered a containment system that will retard waste release rates. Other options could include getter materials, capillary barriers, or other secondary waste capture systems.

Problem Element 1.2.3.2.1 Monitor and Control HLW Immobilization Process. Product quality assurance is a necessary step in HLW immobilization process. The baseline immobilization technology for Hanford, INEL, and SRS is vitrification of HLW; the final waste form must meet both onsite interim storage and final repository disposal requirements. The baseline approach for assuring that these requirements are met at SRS is analysis of the melter feed mixture. The current methodology is slow and will not allow the Defense Waste Processing Facility to meet full throughput rates without enhancements. The baseline methodology at INEL and Hanford is being established, with online monitoring being strongly considered by Hanford.

The technical strategy is to reduce conservatism in the waste form requirements, enhance baseline methods for the SRS, and to develop alternative approaches for Hanford and INEL that can either augment or replace the enhancements used at the SRS. The technical activities being supported by the TFA include

- evaluation of the effective surface area of glass waste forms at Florida International University

- preparation of a Defense Waste Processing Facility mockup facility in which more rapid sample preparation and analytical techniques will be tested and verified for use as product quality assurance at the SRS (Characterization, Monitoring, and Sensors Technology Program).

- develop online monitoring tools, based on user requirements at Hanford.

Problem Element 1.2.3.2.2 Prepare Secondary Waste from Pretreatment. As described in Problem Element 1.2.2.5 Remove Radionuclide, cesium removal is required from alkaline waste supernates to meet LLW disposal requirements. New ion-exchange processes for cesium removal are being developed through the Efficient Separations and Processing Program and demonstrated through the TFA. These new sorbents are being evaluated for cesium removal efficiency, but to fully evaluate them, secondary waste stream generation and treatment must also be considered and technical solutions provided. For example, crystalline silicotitanate appears to have several advantages for cesium removal. It is very efficient and can be used for either in-tank precipitation or out-of-tank processing in ion-exchange columns. The sorbent, however, is not regenerable. As a result, cesium-loaded sorbent material must be processed, most likely using a vitrification process. Concerns have been expressed by users about limitations of titanium loaded in the glass waste form.

The technical strategy is to demonstrate processing of cesium-loaded crystalline silicotitanate from the cesium removal demonstration at ORR. Titanium loading, processability, and waste form performance will be determined so that users can consider the crystalline silicotitanate option in flowsheet development.

Problem Element 1.2.3.2.3 Prepare Sludge. The washed and conditioned sludge stream (described in Problem Elements 1.2.2.7 Process Sludge and 1.2.2.8.2 Sludge HLW Stream to HLW Immobilization) is transferred to a vitrification facility where it must be adjusted chemically with additives before being fed to the melter. During these process steps, slurry pumping and mixing in process tanks is required to ensure a well mixed feed stream. Enhancements to the current methods are needed to improve solids suspension and transfer efficiency at a lower cost.

The technical strategy is to acquire enhanced technology from industry. Specifically, enhanced pumping and mixing technologies will be identified through industry programs and demonstration of these commercially available technologies will occur in side-by-side tests conducted at Florida International University. Technology would be transferred to the SRS user for implementation.

Problem Element 1.2.3.2.4 Immobilize HLW Streams. The baseline technology for HLW processing is vitrification at all of the tank sites with this process being operational at SRS. At SRS, methods that can reduce the cost of operation are being identified and evaluated. Cost reduction can occur through optimization of waste loading that reduces the number of glass logs produced and advanced materials that can reduce maintenance and downtime by reducing corrosion or other materials problems. At the Hanford Site, optimized waste loading and melter selection are considerations for developing the baseline to support phase II privatization. At INEL, waste formulation for sodium-bearing waste and calcined wastes followed by melter testing is needed to meet environmental impact statement and/or records of decision by FY00. Any lessons learned on advanced materials could be included in the Hanford and INEL melter specifications in later years.

Therefore, technical strategy is directed at waste formulation, melter selection, and materials advancement. The following activities are supported by TFA:

- optimize waste loading for components such as iron, aluminum, silicon, zirconium, and alkali cations in SRS and Hanford wastes and determine solubilities in glass of minor components such as chromium, phosphate, halides, technetium and actinides to optimize waste loading of these components; jointly funded by TFA and SRS user program

- establish glass compositions for INEL's sodium-bearing and calcined wastes

- test melters for use at Hanford and INEL

- couple materials producers to melter manufacturers to provide melter components that will extend melter life and reduce maintenance requirements.

Problem Element 1.3.1.3 Define Closure Criteria. A critical question in tank closure is "how clean is clean?". The answer sets retrieval and in-tank treatment requirements and is based on the following:

- characteristics of the tank waste

- potential for release of constituents of concern and the subsequent transport and fate of these materials to environmental and human receptors

- risk to workers to retrieve and process waste

- regulatory requirements

- cost for retrieval or in-place treatment including selective removal of constituents of concern or in situ grouting to immobilize these constituents

- ability (i.e., availability of technology) to retrieve heels or treat residual waste in place to meet regulatory and risk requirements.

Therefore, to answer the question of "how clean is clean?" from a technical perspective, several methods, tools, and technologies are required. Performance data for technologies need to be developed that allow cost-benefit analysis to be completed as part of the decision process. These data ensure that DOE and stakeholders have a sound base upon which decisions on closure requirements can be made.

The technical strategy for defining closure criteria is to conduct integrated demonstrations of characterization, retrieval, and closure systems for different tanks and tank wastes in different environmental settings. The following tanks and technologies have been targeted for this activity:

- samplers and the borehole miner will be used in Tanks 17, 18, 19, or 20 at the SRS to obtain representative samples during characterization to support definition of closure criteria under state wastewater regulations; closure scheduled for FY97 (Waste Retrieval and Closure)

- characterization, sampling, and retrieval systems for closure of single-shell tanks at Hanford, focusing first on Tanks 104-AX and 106-C, will be used; technology from Characterization, Monitoring, and Sensors Technology Program, TFA, and industry will be acquired and deployed to prepare tanks for closure by FY00 (Hanford Tanks Initiative).

- characterization, retrieval, out-of-tank processing, process monitoring, and in situ grouting systems will be used at ORR on the gunite tanks to close the North and South Tank Farms by FY02; technology from Robotics, Industry, Characterization, Monitoring, and Sensors

Technology Programs, and TFA will be used[a]; lessons learned from Subsurface Contaminants Focus Area on multiport grout injection for underground structures will also be used. (Gunite and Associated Tanks-Treatability Study).

A key task that the TFA will support for all of these closure activities is a decision analysis framework that ensures cost-benefit data are consistently collected, analyzed, and reported for use throughout the EM system. Each site can then draw on this resource as closure requirements are negotiated.

Problem Element 1.3.1.7 Stabilize Tank for Closure. Once a tank has been prepared for closure, steps such as physical stabilization to avoid subsidence, containment to reduce or avoid releases from residuals, and environmental monitoring tools to assure tank performance are all needed. The baseline for physical stabilization is being established. At Hanford, a device for filling an empty tank with rocks has been considered. At SRS, options for grouting over waste are being considered to physically stabilize the tank. The baseline technology for reducing releases is being established at the sites; the Resource Conservation and Recovery Act cap is a common first consideration; and the baseline technology for environmental monitoring is well sampling followed by laboratory analysis.

The technical strategy is to rely on new barrier and environmental monitoring systems that have been and are being developed through the Subsurface Contaminants Focus Area and Characterization, Monitoring and Sensors Technology Program, respectively. The TFA will provide user performance requirement input to Subsurface Contaminants Focus Area and as the tank users get nearer to deployment of these technologies, the TFA will support technology transfer.

3.4 TFA Technical Program

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

Therefore the program presented here is focused on continuance of solutions that are carried forward from last year and are on schedule 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 provided by this program. The solutions are primarily aimed at reducing technical risk and offer enhancements to, or fill gaps in, current site baselines.

[a] The characterization, retrieval, out-of-tank processing, and process monitoring tools have already been described in Problem Elements 1.1.3 Characterize Waste In Situ, 1.2.1.1 Deploy Equipment, 1.2.1.2 Mobilize Bulk and Heel Waste, and 1.2.2.4 Clarify Liquids.

Last year, the TFA reported on several technologies that offered early, and relatively certain, site payoffs

- Advanced Hot-Cell Analytical Technology - These technologies were developed as a "rapid response" to Defense Nuclear Facilities Safety Board demands for more effective characterization of Hanford tanks. The technologies were deployed in 222-S Laboratory at Hanford and will provide immediate benefit by using LA/MS for HLW elemental analysis (required to characterize waste and design processing flowsheets), and near infrared scanning for moisture (a safety concern). In addition to providing an early win at Hanford for faster and cheaper characterization data, the technologies will reduce secondary waste generation and personnel exposure. These technologies also have potential applications to other EM remediation problems (e.g., mixed waste).

- Deployment Systems - In April 1996, LDUA was delivered to Hanford for testing. It provides an in-tank multipositioning capability for surveying tank structures, characterizing tank waste, and enabling small-scale waste retrieval. This technology also provides a platform for deploying a range of instruments in tanks and will demonstrate the feasibility of larger-scale mechanical retrieval. Training for LDUA team members from Hanford, INEL, and ORR has also been completed in FY96. The LDUA remains on schedule for demonstration and deployment for separate missions at Hanford and ORR during FY96 and FY97. Formal testing of the LDUA Data Acquisition System was completed, and the LDUA High Resolution Stereoscopic Video System was delivered. An unanticipated implementation of the deployment technology occurred when a scanner, developed in support of the LDUA nondestructive examination end effector, was used to investigate the condition of the fuel pin cladding at INEL. The LDUA will provide a much improved capability to deliver tools to the right spot in a tank.

- Retrieval Process Development - At ORR, INEL, and Hanford, the confined sluicing process uses high pressure jets and low water volume to effectively mobilize hard-to-remove sludges from tanks. It can be extremely useful in tanks that leak or have complex internal hardware that make waste removal more challenging. In FY96, the Confined Sluicing End Effector (CSEE) was successfully developed and delivered for the removal of the heels in Tanks W3 and W4 as part of the ORR Gunite and Associated Tanks Treatability Study. During FY97, the deployment of the CSEE in a radioactive waste tank at ORR will be supported by the RPD&E activity of the TFA. This CSEE technology will also be evaluated under both vehicle and MLDUA deployment. In FY97, an extendible nozzle will be deployed in Tank 19 at SRS to mobilize a hard zeolite heel for further characterization. Another retrieval technology, Pulsair, removes waste by introducing large gas pulses at 690 to 2,070 kPa (100 to 300 lb/in^2). In FY97, the Pulsair technology will be prepared for deployment in a radioactive waste tank.

- Alkaline Cesium Removal - The FY96 cesium removal demonstration at ORR described in the FY96-98 MYPP was to provide critical data on the most cost-effective sorbents to use within different flowsheets. This supports key processing decisions related to selecting ion-exchange sorbents (at ORR), in-tank precipitation alternatives (at SRS), and baseline cesium removal processes (at Hanford). Thus far in FY96, the demonstration system was procured and installed at ORR. The plan is to operate the system to treat 83,279.06 L (22,000 gal) of Melton Valley

Storage Tank supernate beginning in FY96 and continuing into FY97. Crystalline silicotitanate has been selected for the demonstration, and laboratory test columns on actual waste have been run to develop data needed for the demonstration.

- Waste Processing and Tank Closure Demonstration - The TFA has joined with SRS to conduct a waste retrieval and closure demonstration in two tanks at SRS over the period FY96-98. Low cost saltcake retrieval will be demonstrated by using the modified density gradient method in Tank 41. The objective is to develop cost and performance data for saltcake removal and clean out for in-tank precipitation processors. An extendible nozzle will be deployed in Tank 19 to mobilize the hard zeolite heel remaining from mixer pump retrieval. The mobilization will help further characterize the heel and help establish cleaning criteria and tank closure. The objective is to develop and implement closure criteria and strategies to close a HLW tank. Data from these tests will be major contributions to tank decision processes at the four DOE tank sites.

The above tasks provide evidence of the TFA's response to its technology development challenge. Yet, the knowledge acquired in the past year helped the TFA develop a more strategic approach to tanks technology development integration. An outcome was TFA's identification of four technical strategic goals:

- demonstrate, deploy, and provide performance data for four tank waste retrieval systems to meet EM's FY00 requirements

- provide tank waste treatment technologies that can efficiently pretreat and immobilize 80% of HLW

- demonstrate compact processing units for HLW treatment and immobilization as a cost-effective alternative to large-scale facilities

- provide subsystems necessary to support the closure of 16 radioactive waste storage tanks: Hanford (2), Oak Ridge (10), and SRS (4).

These strategic goals provide a more definitive program focus that ties critical complex-wide requirements to site needs. The TFA's development and execution of technology development tasks will reflect aggressive pursuit of these goals. Figure 3.2 identifies the relationship between these strategic goals and the key EM projects focused on meeting these goals. These key EM projects represent joint TFA and EM-30 or EM-40 site users' efforts to meet high-impact site retrieval, pre-treatment, immobilization, and closure needs. The projects are critical to meeting the sites' missions, reducing mortgages, and meeting the TFA's strategic goals.

Specific TFA activities in support of these strategic goals are described within the previously introduced problem element structure shown in Table 3.1. In Table 3.1, the problem elements in bold type are those for which the TFA is developing a response to high-impact needs identified in the site needs assessment. The high-impact needs were designated by the TFA in coordination with the sites. For those problem elements receiving a TFA response, Table 3.2 presents the problem element titles, summaries of the problem statement, path to solution, and planned work scope. More detailed descriptions of these problem elements are provided in Appendix B. Each problem element is directly associated with multiple technical activities funded by EM-30, EM-40, or EM-50. FY96 activities that may be leveraged or coordinated in FY97 have been identified and will be integrated into this plan as EM-30 and EM-40 complete their FY97 planning process. Table 3.3 shows the estimated EM-30, EM-40, and EM-50 funding for each of the technical elements. Section 4 and Appendix B provide additional detail of this integration.

The requested budget for the TFA-managed technical program is $30.5 million for FY97 and $40.6 million for FY98 (see Table 3.3). This FY98 budget is the "above planning" unconstrained budget estimated for the "right program." The planning level budget for FY98 is $33 million. The work scope identified in this MYPP was based on the "above planning" budget. Therefore, work activities planned for FY98 and FY99 may need to be delayed or rescoped depending on the actual budget level authorized for FY98. These figures are $75.7 million and $85.9 million, respectively, when activities in technology integration and the crosscutting, industry, and university programs are integrated. The fully coordinated budget for the recommended program, including EM-30, EM-40, and EM-50 funding, is $100.5 million for FY97 and $100 million for FY98. These figures reflect currently requested crosscutting and site-specific program budgets for activities that are either directly leveraged,[a] strongly coordinated,[b] or potentially leveraged[c] with the focused multisite program.

3.5 Assumptions for the Recommended Technical Program

The TFA has made programmatic and technical assumptions about tank waste remediation when developing the recommended technical program. General programmatic assumptions are shown below.

- Hanford Federal Facility Agreement and Consent Order, 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 the possibilities of privatization and significant site remediation budget reductions.

(a) Directly leveraged - Budgets, scope, and schedule have been integrated in existing technical task plans or activity data sheets.
(b) Strongly coordinated - Scopes depend 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.

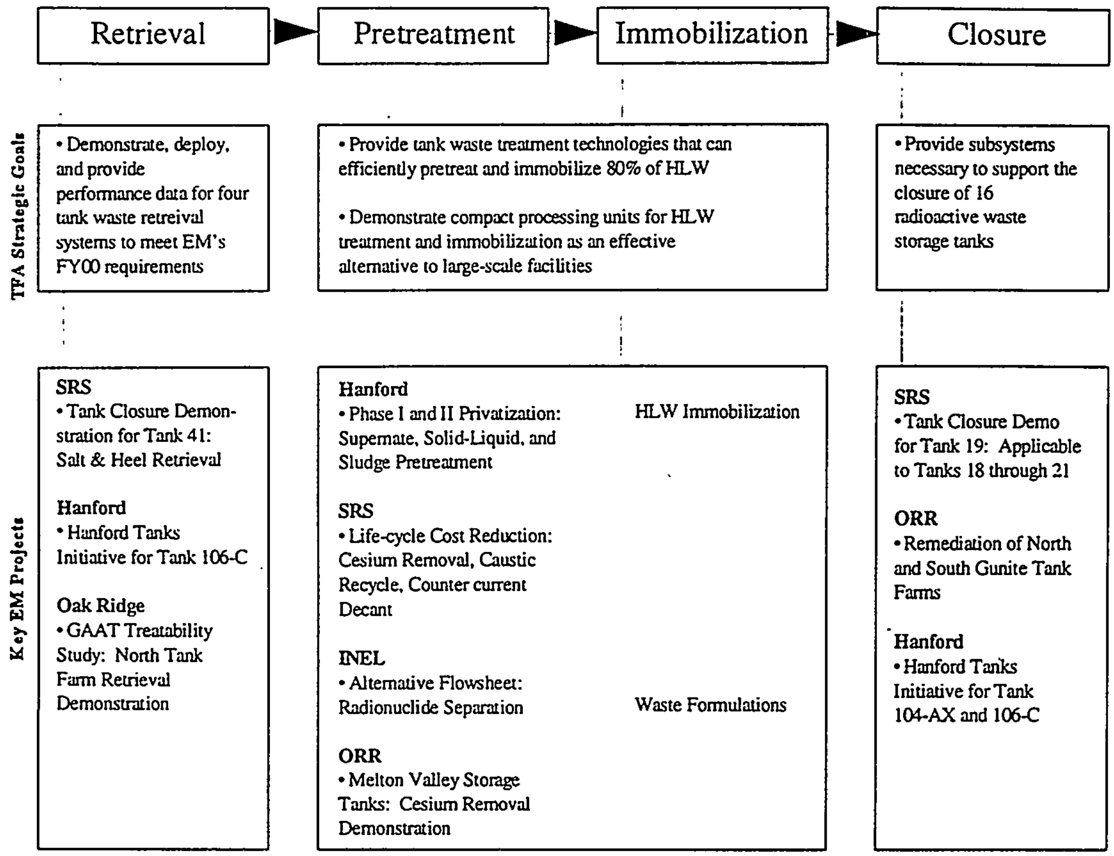

Figure 3.2. Relationship of TFA Goals to Key EM Projects and Tank Waste Remediation System Functional Components

Table 3.2. Scope of Recommended TFA Technical Program

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.1.1.1 Monitor Tank Integrity	There is a need to perform nondestructive examination of tank walls to determine structural integrity. Current methods are limited to contact examinations and usually require a cleaned surface and coupling between the head and structure being inspected. A real-time tank corrosion monitoring method is needed to provide early detection of potential problems that may lead to leakage or structural failure.	• Evaluate commercial and other nondestructive examination systems to meet INEL's need for tank integrity inspection. • Develop and deploy an LDUA-delivered end effector for Nondestructive examination inspection in INEL's waste tanks. • Identify and evaluate monitors for NO_3^-/NO_2^-/OH^- to maintain corrosion inhibitor concentrations at Hanford.	• Evaluate availability of other nondestructive examination technologies. • Develop a field deployable end effector for the LDUA system. • Demonstrate and deploy the LDUA-delivered nondestructive examination system in an INEL waste tank. • Conduct cold testing of corrosion inhibitor monitors and initiate hot demonstration. • Validate performance of NO_3^-/NO_2^-/OH^- monitors and transfer for deployment.
1.1.1.2 Avoid Tank Corrosion	Hanford, SRS, and ORR all have carbon-steel tanks with neutralized waste. These sites have reported leakage resulting from tank aging (corrosion). Tank leakage has occurred to a large extent in tanks that have not been heat treated. Corrosion in transfer lines at each site has been an safety issue as well as a transfer issue.	• Evaluate the state-of-the-art in corrosion prevention relative to underground storage tanks. • Develop performance specifications. • Develop advanced corrosion prevention methods based on user input to performance specifications. • Demonstrate and evaluate methods for deployment at DOE sites.	• Conduct a workshop to develop performance requirements for corrosion prevention and assess the status of active work in this area. • Issue procurement for advanced corrosion prevention technology. • Demonstrate methods for corrosion prevention.
1.1.3.1 Characterize Waste In Situ	At Hanford, characterization of each full-length core is expensive and time consuming. The planning basis for core retrieval at Hanford is to retrieve over 400 full-length cores. In situ characterization would reduce costs, personnel radiation exposure, and generation of secondary radioactive waste streams. At INEL, characterization of the tank heels and residual waste or contamination may be required before the state and Federal agencies will grant closure permits.	• Develop and test a CPT system with Raman spectroscopy probe. • Deploy the CPT/Raman as part of the Hanford Tanks Initiative to support closure of Tanks 106-C and 104-AX at Hanford. • Develop, test, and deploy a Minilab system for use on the LDUA for in-tank characterization of physical and chemical waste properties.	Hanford: • Prepare an operations manual for the CPT/Raman. • Conduct cold field test runs to train operators on the Raman spectrometer and CPT system. • Increase the performance of the Raman probe. • Complete technology transfer to Hanford site users. INEL: • Fabricate the Minilab based on the functions and requirements identified in 1996. • Qualify the Minilab for operation. • Deliver and deploy the Minilab at INEL for in-tank characterization activities.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.1.3.2 Sample Waste	Currently applied auger, push, and coring technology is limited to vertical tank sludge/saltcake sampling directly under available risers. Most tanks are limited to one or two risers for sampling, insufficient to provide adequate samples for the horizontal profile of tank waste characteristics.	• Assess feasibility of off-riser sampling. • Procure industrial system. • Cold test system with simulants. • Demonstrate off-riser sampling in a waste tank.	• Complete assessment of commercial feasibility of off-riser sampling. • Design and procure an off-riser sampling system from industry. • Conduct operations testing in a cold test environment. • Demonstrate off-riser sampling system in a hot waste tank at Hanford.
1.1.3.3 Analyze Waste	High cost and long time periods are required to conduct a complete suite of physical and chemical analyses on tank waste cores. Development of remote analytical scanning technologies are needed to reduce the cost, time, personnel exposure, and generation of secondary waste when characterizing solid radioactive core segments and samples from tank wastes.	• Develop/adapt a commercial LA/MS for hot-cell applications. • Conduct laboratory testing to verify instrument effectiveness. • Deploy LA/MS system in hot cell and test with actual core samples. • Complete technology transfer to Hanford's analytical laboratory.	• Continue LA/MS software development. • Develop and validate a method for monitoring the ablation and feed rate of ablated aerosols. • Complete technology transfer to Hanford 222-S Laboratory.
1.1.4.2 Reduce Recycle Streams	Start up of treatment processes produces additional recycle and secondary waste streams that must be additionally treated before release to the wastewater treatment process and discharge. Technologies are needed to treat this moderately contaminated stream to prevent recycle to the full treatment process.	• Develop specifications and procure a commercial system for adaptation to the treatment of the Defense Waste Processing Facility recycle stream. • Demonstrate the pilot system at SRS.	• Develop performance specifications for a modular treatment process to remove mercury and organics from the SRS recycle stream. • Procure the design and fabrication of a pilot-scale treatment system. • Plan a demonstration to treat recycle water contaminated with radionuclides and hazardous wastes.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.2.1.1 Deploy Equipment	Hanford: Characterize the AX-104 tank heel and deploy cost effective retrieval processes for Tank C-106 to support HTI. ORR: As part of the Gunite and Associated Tanks - Treatability Studies, plan, design, execute, and operate a closure demonstration on one of the gunite tanks. As part of this closure demonstration, there is a need for an LDUA system. INEL: There is a need for an LDUA system to support characterization, safety, and retrieval functions. Multisite System Deployment: An entire class of needed technology must be obtained from industry, developed, adopted for tank use and implemented at one or more sites to enable characterization, safety, and retrieval equipment to be deployed within the tanks, including • tank integrity and leak investigations • characterization sampling of wastes and in situ waste analysis • visual waste and tank inspection • tank mapping • interim stabilization • annulus inspection and cleaning • retrieval of heels and other hard-to-remove wastes • assisting in the removal of in-tank hardware • decontamination of empty tank • closure activities.	Hanford: Adapt the LDUA to support characterization; procure and evaluate additional industry technology; deploy characterization and retrieval technology. ORR: Complete development, delivery, and initial deployment of the modified LDUA; transfer LDUA for full deployment. INEL: Multisite System Deployment: • Complete transfer of the LDUA to Hanford. • Integrate and test sampling and inspection end effectors and control systems to support site missions. • Conduct mission studies to determine the varied site deployment technology needs and performance requirements. • Review available industry technologies. • Design development and test programs to evaluate commercial technology performance. • Support site deployments.	Hanford: Provide deployment devices, specification development, and design support needed to deploy characterization and retrieval tools in selected tanks. ORR: Complete delivery, integration, and testing of the Modified LDUA; demonstrate waste heel retrieval in North Tank Farm Gunite tanks. INEL: Complete LDUA system acceptance testing and operator training; support LDUA deployment; complete end effector integration and testing for Minilab, remote viewing, sampling and nondestructive examination systems. Multisite System Deployment: LDUA efforts will be focused on transfer for implementation. For deployment, the primary work activities will include development of a formal, site coordinated strategy, requirements and needs for deployment in tanks, and development of a database of deployment technologies. Alternative deployment devices will also be sought that are simpler than the LDUA and that will complement its capabilities.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.2.1.2 Mobilize Bulk and Heel Wastes	The DOE complex has horizontal and vertical cylindrical steel and concrete waste storage tanks that require remediation. Removal of bulk saltcake and sludge, saltcake heels, hard sludge heels, and possibly debris will be required. Alternative approaches to the hydraulic mining baseline are required for retrieval of the hard sludges, or bulk waste retrieval in leaking tanks where water use is restricted, as well as removal of debris and contaminated floor and wall segments. There is also a need for technical support for producing functions and requirements documents and prototypic hardware to allow sites to procure the right equipment.	• Deliver, deploy and evaluate performance of the Confined Sluicing End Effector for waste retrieval at ORR. • Complete testing of the Light-Weight Scarifier. • Procure and evaluate additional industry and international technology to support site needs. • Develop, produce, and validate waste simulants for use in developing, testing, and qualifying waste retrieval processes. • Conduct a Waste Removal and Closure Demonstration at SRS.	<u>CSEE</u> • Deploy in the ORR gunite tanks during FY97. <u>Light-Weight Scarifier</u> • Integrate and demonstrate at ORR in the gunite tanks. • Develop retrieval models to predict the cost and efficiency for potential applications at Hanford and INEL and as compared to the CSEE. <u>Industry Technology Evaluation</u>: Procure and evaluate additional industry and international technology. <u>Waste Retrieval and Closure Demonstration</u>: Continue the salt and zeolite heel removal demonstration at SRS.
1.2.1.5 Detect and Mitigate Leaks	Measurement of waste tank liquid levels can have accuracies on the order of 1,000s of gallons. Improved methods for leak detection are needed to prevent unplanned release of radioactive waste in the event leakage occurs during retrieval. Leakage during sluicing and other types of waste removal will be an issue with states, regulatory agencies, stakeholders, and sites. Two general types of leak prevention technologies, repair and mitigation, need to be investigated and alternatives evaluated.	• Demonstrate the electrical resistance tomography technology for leak detection at Hanford. • Evaluate state-of-the-art in leak mitigation and repair within DOE, U.S. industry, and internationally. • Develop multiyear program to develop, test, and demonstrate systems for leak mitigation and repair based on user input on performance requirements and the current technology status.	<u>Leak Detection</u> • Develop a strategy for leak detection and monitoring during retrieval of potentially leaking tanks. • Deploy the electrical resistance tomography around a selected Hanford tank to support potential leak determination during sluicing operations. <u>Leak Repair</u> • Assess DOE's leak mitigation and repair requirements and initiate development and testing program. • Provide users performance and cost data on leak mitigation and repair.
1.2.1.6 Monitor & Control Retrieval Process	In situ tank and transport line sensors to measure slurry density, mass flow, viscosity, and volume % solids are needed. Retrieval and transfer activities in need of near-term slurry monitoring include ORR GAAT and Hanford tanks undergoing retrieval as part of HTI. A downselect of the appropriate monitors, installment, and field testing is needed prior to FY98 to provide validated on-line slurry monitoring.	• Develop and procure slurry monitors. • Test and evaluate performance of slurry monitors relative to user-defined specifications. • Deploy appropriate slurry monitors at ORR and Hanford.	• Comparative testing of the prototype ultrasonic slurry monitor against other sensors. • Select and deploy the most appropriate sensors for ORR and Hanford based on comparative testing. • Validate monitor based on actual deployment at ORR and Hanford.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.2.1.7 Integrate Retrieval and Pretreatment Technology Systems	A comprehensive methodology for matching the combination of technologies for a particular tank waste or blend of tank wastes is not available. An integrated tool is needed to ensure users can reliably evaluate alternative processing approaches and system configurations and compare them based on multiple criteria.	• Develop performance and cost tools for retrieval pretreatment processing to aid users in developing process flowsheets and to aid DOE in evaluation of proposals as privatization proceeds. • Deploy process analysis tools on user-defined priority tanks to directly support decisions on the highest priority tanks.	• Compile data on tank waste characteristics and pretreatment processing performance. • Assemble retrieval tool performance, tank geometry, and waste characteristic data. • Model major pretreatment processes to allow performance predictions to be made under a variety of tank waste scenarios. • Develop and prototype process analysis tool for selected site problems. • Deploy process analysis tools on user-defined priority tanks.
1.2.2.1 Calcine Waste	The INEL sodium-bearing waste is not compatible with the current fluidized bed calcination flowsheet at 500°C because of incomplete conversion of the nitrates to oxides and the formation of agglomerated particles in the calcine. Processing: Alternatives include high temperature processing and sugar additive calcination to improve denitration. Process Monitoring: Development of real-time process control monitoring will be needed to 1) measure hydrocarbons in calcine offgas fines and 2) measure elemental species in the calcine product .	• Optimize the calcining flowsheet to handle sodium-bearing wastes through pilot-plant studies. • Adapt and demonstrate a laser-induced breakdown spectrometer for on-line process monitoring.	Processing: • Develop a process flowsheet, specifications for process equipment, and test prototype system for thermal denitration. • Perform demonstration testing based on the FY97 results to support the full-scale design team with engineering performance and cost data. Process Monitoring: • Adapt existing laser-induced breakdown spectrometer instrument for testing with the high-temperature fluidized bed calcination process. • Demonstrate the laser-induced breakdown spectrometer system at INEL.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.2.2.3 Prepare Retrieved Waste for Transfer and Pretreatment	Two primary issues exist: 1) sludge and saltcake chemistry and its impact on dissolution rates, pipeline transfers, and mixing operations, and 2) sludge physical properties and their impact on the pipeline transfer and mixing operations.	• Establish a testing program on Hanford Tank 106-C soft and hard sludges. Obtain critical chemical and physical properties that influence bulk waste transport properties. • Evaluate sludge physical properties affecting waste transfer and develop performance specifications for acceptable waste physical properties. • Conduct studies with dry, hardened SRS sludges.	• Conduct tests on 106-C that have been subjected to conditions that simulate mechanical and hydraulic mobilization of sludge. • Explore conditions that alter critical chemical and physical properties. • Collect and characterize samples of Hanford waste for particle size, hardness, and rheology. • Perform simulant studies for rheological properties in transfer lines. • Conduct aging studies on simulated SRS sludges. • Conduct laboratory-scale studies on actual SRS sludge samples.
1.2.2.4 Clarify Liquid Stream	All four sites identified solid/liquid separation (SLS) as a critical problem. Testing of alternative filter systems is required to support the separation of undissolved solids from the sodium bearing and dissolved calcine wastes at INEL, the late wash precipitate at SRS, various LLLW streams at ORNL including TRU sludges, and Sr/TRU-bearing retrieval solutions, and supernatants and wash solutions for Phase I privatization at Hanford.	• Identify industrially- and internationally-available enhanced filtration systems to meet multi-site needs • Perform lab- or bench-testing of advanced filters with simulated wastes • Deliver bench-scale filter systems to the sites for hot testing • Provide technical support to sites in selection and testing of full-scale filter systems • Conduct full-scale demonstration on solid-liquid separation at ORR as part of GAAT treatability study	• Complete testing of radioactive wastes using the Cells Unit Filters at Hanford. • Complete demonstration of crossflow filtration unit during gunite and associated tanks treatability studies at Oak Ridge National Laboratory. • Construct and test a Cells Unit Filters unit designed for remote radioactive service at INEL. • Continue filter testing of the SRS Defense Waste Processing Facility recycle. • Test Russian technology on U.S. waste streams for solid-liquid separation. • Conduct full-scale solid-liquid separation on retrieved sludges from gunite tanks.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.2.2.5 Remove Radionuclides	Cesium Removal from Alkaline Wastes: Alternative cesium removal technologies are desired for SRS to backup the baseline in-tank precipitation process and allow potential improvements in efficiency and life-cycle costs. For ORR, performance and cost data from actual processing is needed to ensure that deployment of Cs removal using CST is appropriate. At Hanford, there is a need to ensure that technology can meet stringent waste acceptance criteria. Radionuclide Removal from Acid Wastes: Treatment technologies applicable to transuranic elements including strontium, technetium, TRU, and cesium in INEL waste streams must be developed and tested to provide cost and performance data for final baseline technology selection. Technetium Removal from Alkaline Wastes: To meet performance requirements for the LLW form at Hanford, technetium must be removed from the supernate in select tanks before immobilization. Anion exchanges are less effective if non-pertechnetate forms of technetium are in solution. Technetium removal technologies and/or procedures that can address this non-pertechnetate problem must be developed and/or demonstrated on actual waste. Other Radionuclides Removal from Alkaline Wastes: In addition to the needs for removal of cesium and technetium from supernates at the four sites, needs also exist for improvements to or alternatives to the baseline removal processes for other radionuclides, especially strontium.	Cesium Removal from Alkaline Wastes: • Complete demonstration and transfer the CST removal system for use on cesium at ORR. • Conduct laboratory- and bench-scale tests on a variety of sorbents and waste types at SRS and Hanford to develop performance and cost data. • Demonstrate an alternative process for cesium removal at SRS. • Provide engineering performance and cost data on cesium separation alternative to Hanford and SRS. Radionuclide Removal from Acid Wastes: • Select appropriate separations processes for TRU, technetium, strontium, and cesium removal. • Test and demonstrate methods for TRU, technetium, strontium, and cesium removal over a 3-year period • Produce performance and cost data to support INEL decision on their baseline radionuclide separation unit operations. Technetium Removal from Alkaline Wastes: • Perform batch tests and flow studies. • Develop and test methods for separating reduced technetium. Other Radionuclides Removal from Alkaline Wastes: • Demonstrate alternative methods for strontium removal. • Investigate and develop processes for treatment of free-phase organics from sludges in Hanford's Tank 106-C. • Evaluate sorption processes.	Cesium Removal from Alkaline Wastes: • Complete demonstration and reporting on CST removal of cesium at ORR. • Conduct bench-scale tests on six Hanford waste tank supernates with two cesium-removal sorbents. • Conduct batch tests with granular CST for SRS. • Perform bench-scale column studies with CST on SRS supernates. • Demonstrate in-tank or out-of-tank processes (depending on FY 98 results) for improved cesium removal at SRS. Radionuclide Removal from Acid Wastes: • Demonstrate strontium removal on actual tank waste using the countercurrent strontium extraction flowsheet. • Evaluate performance of calcine dissolution at the bench-scale and demonstrate TRU extraction on dissolved calcine. • Demonstrate cesium removal using sorbents and processes identified in FY97. Technetium Removal from Alkaline Wastes: • Perform small sorbent batch tests. • Complete continuous flow studies. • Survey available technologies for removal of reduced forms of technetium. • Scale chemical concepts continuous system to provide engineering data. Other Radionuclides Removal from Alkaline Wastes: For ORR, perform small-scale batch contacts in hot cells for ruthenium removal; for Hanford, complete technology screening and larger scale tests, conduct studies, and demonstrate the Sr-Talk process.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.2.2.7 Process Sludge	Sludges at SRS, Hanford, and ORR will require processing to remove nonradioactive constituents that either adds to the volume of the resulting HLW (e.g., aluminum) for impacts immobilization processing (e.g. chromium, technetium, or phosphate). Technical problems and issues exist in three areas of sludge processing: performance data on the baseline enhanced sludge washing system, sludge washing chemistry, and continuous sludge processing.	Baseline Enhanced Sludge Washing: • Conduct laboratory-scale testing of the baseline enhanced sludge washing flowsheets to evaluate separation efficiency. • Perform an engineering-scale demonstration of enhanced sludge washing and sludge separation to confirm operating performance. Sludge Washing Chemistry: • Evaluate methods to remove chromium, iron, and other problem metals from wastes to meet performance requirements. • Test enhancements to sludge washing. • Demonstrate improved sludge washing methods on Hanford and ORR waste streams. Continuous Sludge Processing: Test and demonstrate continuous-flow sludge processing equipment as a higher efficiency alternative to batch methods.	Baseline ESW: • Conduct small-scale laboratory tests on actual Hanford sludge waste. • Demonstrate, at an engineering-scale, the batch processes of the Hanford baseline flowsheet. Sludge Washing Chemistry: • Evaluate methods to remove chromium from waste by oxidizing the insoluble Cr^{+3} to soluble Cr^{+6}. • Conduct chemical tests on iron removal by acetohydroxamate or oxalic acid. • Conduct alkaline processing tests. • Evaluate gelation and colloid formation during caustic leachate testing. • Evaluate sonification to physically enhance sludge leaching. Continuous Sludge Processing: • Demonstrate continuous-flow sludge pretreatment technologies. • Design, fabricate, and operate a pilot-scale countercurrent decantation system to support SRS processing.
1.2.2.8 Prepare Pretreated Waste for Immobilization	Supernate Stream to LLW Immobilization: Significant quantities of sodium hydroxide (caustic) will be required to store and retrieve HLW and leach sludges at Hanford and SRS. Addition of fresh caustic will significantly increase the quantity of waste requiring disposal. Sludge HLW Stream to HLW Immobilization: The current flowsheet at Hanford and SRS transports dilute and variable sludge directly to the vitrification system. The vitrification system must be over-sized to handle the excessive water and heat-load requirements. Commercial techniques are available for moisture and organic extraction, but this has not been evaluated for potential application on tank sludge.	Supernate Stream to LLW Immobilization: • Conduct bench-scale tests of salt splitting and membrane separation methods for caustic recycle. • Perform long-term bench testing to determine process equipment longevity. • Conduct a pilot-scale demonstration of caustic recycle using the preferred process(es) identified during bench-scale testing. Sludge HLW Stream to HLW Immobilization: • Identify and down-select promising commercial sludge conditioning equipment. • Demonstrate most promising methods on surrogate sludge wastes.	Supernate Stream to LLW Immobilization: • Demonstrations caustic recovery using radioactive liquid waste obtained from Tank 50H or the saltstone. • Conduct a long-term bench-scale test to establish membrane and other cell component durability. • Demonstrate scale-up of the caustic recovery process using the preferred membrane. Sludge HLW Stream to HLW Immobilization: • Compile chemical and physical properties of treated sludges and identify industrial sludge conditioning equipment potentially applicable. • Conduct surrogate waste testing of sludge conditioning equipment.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.2.3.1.1 Monitor and Control LLW Immobilization Process	A faster, cheaper method than neutron activation for technetium-99 analysis is needed for process control. On-line analysis would be needed to avoid producing TRU waste and analysis of Resource Conservation and Recovery Act metals would be needed to maintain metal concentrations below levels which would be considered a mixed waste. Many of the specified test methods were not developed for testing of glass. Methods are needed to verify conformance with specifications before DOE takes custody of the products from the private sector.	• Evaluate waste form compliance requirements that will drive monitoring and control specifications. • Evaluate adequacy of existing technology to meet specifications. • Develop and demonstrate validated test methods, instrumentation, and standards for waste form acceptance testing.	• Collect and assess waste form compliance requirements. • Identify appropriate test methods and standards. • Determine the accuracy and precision expected for each method (both existing and developed as a part of this program). • Develop and demonstrate test methods and on-line instrumentation to monitor product control specifications. • Deploy waste form acceptance monitors for selected site use.
1.2.3.1.3 Immobilize LLW Stream	Disposal of low-activity tank wastes is being approached very differently at individual DOE sites, and, in some cases, even within a single site. Specific technical issues and needs exist at the sites for selection of the most appropriate and acceptable waste forms.	• Develop specifications/functional requirements for grout waste formulations for INEL and grout and glass waste forms for ORR. • Test and evaluate grout formations for INEL's high aluminum, zirconium, and sodium wastes. • Demonstrate and evaluate grout and glass waste forms for ORR.	• Define the range of waste compositions representing the variety of ORR waste types and blends likely to be encountered. • Develop and test acceptable grout and glass formulations using simulated wastes. • Develop/ test grout formulations for the immobilization of INEL's low-activity waste. • Obtain engineering performance data for INEL's low-activity waste immobilization.
1.2.3.2.1 Monitor and Control HLW Immobilization Process	After the immobilized waste form is produced, methods for acceptance inspection and testing of the waste form are needed to verify conformance with specifications before DOE takes custody of the products from the private sector.	• Identify performance specifications for on-line instrumentation • Develop instrumentation for process feed and produced waste form analysis • Demonstrate on-line instrumentation in support of Hanford's phase I privatization, and to augment SRS Defense Waste Processing Facility processing.	• Identify performance specifications and limitations of available technology for on-line monitoring of immobilization process feed and waste product. • Develop and demonstrate on-line instrumentation for monitoring product control specifications for the immobilization process feed streams. • Develop and demonstrate instrumentation for product acceptance inspection after the waste form was produced.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.2.3.2.2 Prepare Secondary Waste from Pretreatment	As with all ion-exchange resins, CST resin disposal may require subsequent processing. Specifically, ORR requires engineering performance and cost data on ion-exchange resin vitrification to support a decision on secondary waste CST resin disposal. A key technical issue with CST resin vitrification is the ability to incorporate significant waste quantity into the glass waste form.	• Demonstrate immobilization of spent ion-exchange resins from a cesium separation process., • Provide engineering and cost performance data to users to support implementation of secondary waste vitrification.	• Load CST resin with cesium as part of the MVST demonstration. • Transport loaded resin from ORR to the SRTC's Shielded Cells for immobilization testing. • Demonstrate two immobilization processes: a sludge-CST glass process, and a CST-only glass process. • Characterize important process parameters during immobilization. • Provide engineering performance to ORR and other sites. • Dispose of the waste glass product to the Nevada Test Site.
1.2.3.2.3 Prepare Sludge Feed	Sludge mobilization and transfer are directly impacted by the selection of sludge feed processing operations. In vitrification facilities, the process is controlled through control of the feed composition. If melter feed is not well mixed, it will affect process and equipment reliability. Performance of the sludge feed system needs to be enhanced.	• Establish requirements for mixing and handling waste sludges. • Procure and evaluate commercial system that meet functional requirements.	• Develop functional requirements for agitation and sampling systems. • Demonstrate commercial systems and evaluate performance relative to the functional requirements.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.2.3.2.4 Immobilize HLW Stream	Advanced Materials for Vitrification at Hanford and SRS: Corrosion of materials in specific environments has been observed. Vitrification of INEL High-Activity Waste: Technology for immobilization of the high-activity waste fraction must be identified and evaluated so that a plan and schedule for the waste treatment facility can be negotiated. Advanced Immobilization Systems for Hanford: Testing of alternative processes with representative waste simulants is needed to produce engineering performance and cost data to support final technology selection at Hanford. Optimization of Glass Component Solubility: For SRS tank wastes and much of the Hanford tank waste, the major waste components will determine the waste loading by affecting important process and product parameters. Methods are needed to increase the levels of these components which can be included in waste glasses.	• Identify life-limiting conditions for melter materials, and test promising advanced materials. Test and evaluate commercial advanced immobilization processes using waste simulants. • Develop and test melter materials and glass formulations and demonstrate a process for the immobilization of INEL high-activity waste in conjunction with EM programs funded by INEL. • Identify methods to optimize key component solubility in waste glass to support both secondary waste and improved HLW vitrification.	Advance Materials • Define and evaluate life-limiting conditions for vitrification and offgas process equipment. • Identify promising candidate materials for specific service conditions. • Evaluate the performance of selected material samples. Vitrification of INEL High-Activity Waste: Perform materials corrosion and vitrification tests on simulated waste; verify with actual wastes. Advanced Immobilization • Procure waste simulants. • Evaluate melter systems. Optimization of Glass Component Solubility • Develop methods to maximize the content of minor components in glass. • Test promising methods for maximizing component solubility in small continuous melters. • Provide engineering performance and cost data and recommendations on enhancements.
1.2.3.2.5 Treat HLW Offgas	Effective control of vitrification processes, and a reliable design of process equipment, require an understanding of the interactions between feed composition and melter conditions. An understanding of these interactions is also essential for preventing or remediating corrosion problems in melter vapor space and offgas systems, and for optimizing waste loading in glass.	• Develop models to predict glass offgas compositions from vitrification operations. • Integrate the model into commercial simulation packages for use by the sites in designing and optimizing vitrification process equipment selection and operations.	• Adapt existing models of glass melting behavior. • Validate the model with test data from appropriate melting tests. Validation will occur with results independent of any data used to develop the model. • Integrate the model with commercial process simulation packages.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.3.1.3 Define Closure Criteria	Hanford, SRS, and ORR are pursuing closure or preparation for closure of waste tanks during the FY96-99 time frame. A key issue is the definition of retrieval performance and closure criteria and defining "how clean is clean?". At SRS, an evaluation of the variety of alternative closure options (in addition to grout over the waste) needs to be performed and source term conceptual models need to be developed. At Hanford, performance and cost-based closure criteria for Hanford's Tanks 104-AX and 106-C are needed that are acceptable to DOE, its regulators, and interested stakeholders.	• Complete assessment of tank closure options for SRS Tank 19. • Develop recommendations on post-closure monitoring options consistent with the negotiated performance objectives for SRS. • Build off of SRS and ORR experience to support the HTI. • Identify and evaluate retrieval performance objectives and technical options for Hanford Tanks 104-AX and 106-C with stakeholder and user input. • Provide technical, cost, and risk performance evaluation data to user to aid in determination of a preferred closure strategy for tanks 104-AX and 106-C. • Initiate a joint TFA-ORR closure demonstration • Initiate a joint TFA/ORR demonstration similar to the Waste Retrieval and Closure Demonstration at SRS. • Assess vadose zone contamination around Tank 104-AX.	SRS • Evaluate disposal configuration options for tank closure; perform a concept study for treatment walls; evaluate appropriate long-lived radionuclide "getters." • Conduct a performance evaluation for selected preferred disposal options. • Recommend closure monitoring strategies Hanford • Identify regulatory requirements and evaluate performance objectives. • Determine various tank closure configurations and establish a baseline conceptual model • Conduct a study of alternatives for clean closure of the tank farms. • Develop information to support NRC's determination of residual waste classification.

Table 3.2. (contd)

Problem Element	Problem Statement	Path to Solution	FY97-FY99 Scope
1.3.1.7 Stabilize Tank for Closure	The Hanford Site needs knowledge and concepts to characterize the soil surrounding the waste tanks and to stabilize the waste tanks, if required, by • adding materials that preferentially capture and retain those radionuclides that contribute the most to the risk consequences of the waste residue in the tank • developing data on potential barrier performances that can reduce the water recharge rates to the stabilized tanks • developing concepts and designs that divert away any recharge water that penetrates the surface barrier.	• Assess current state of the art in closure strategies and options. • Develop new closure strategies based on regulatory performance requirements. • Test and validate appropriate closure options for Hanford and other sites' use.	This activity will investigate closure strategies that result in better retention of radionuclides in the stabilized waste tank. Specifically, this activity will • review state-of-the-art closure strategies and develop and design new closure strategies and options based on negotiated closure requirements and performance objectives • develop the validation data for these new strategies. A database will be developed of closure options and their performance parameters will be developed to ensure an adequate decision base is available for the HTI.

CPT cone penetrometer
CST crystalline silicotitanate
DOE U.S. Department of Energy
EM Office of Environmental Restoration and Waste Management
HLW high-level waste
HTI Hanford Tanks Initiativer
INEL Idaho National Engineering Laboratory
LAIMS laser ablation/mass spectrometer
LDUA Light-Duty Utility
LLW low-level waste
MVST Melton Valley Storage
NRC U.S. Nuclear Regulatory Commission
ORR Oak Ridge Reservation
SRS Savannah River Site
SRTC Savannah River Technology Center

Problem Element#	Problem Element Title	EM-30/40	FY99[a] TFA	EM-50XC[b]	EM-30/40	TOTAL
1.1.1.1	Monitor Tank Integrity		200			984
1.1.1.2	Avoid Tank Corrosion		800			1,950
1.1.3.1	Characterize Waste In Situ	3,000				14,187
1.1.3.2	Sample Waste		1,000			2,627
1.1.3.3	Analyze Waste					6,075
1.1.4.2	Reduce Recycle Streams		1,000			3,048
1.2.1.1	Deploy Equipment	1,750	10,100			46,490
1.2.1.2	Mobilize Bulk and Heel Wastes	1,000	2,300			23,203
1.2.1.5	Detect and Mitigate Leaks		1,200			5,294
1.2.1.6	Monitor and Control Retrieval P					3,915
1.2.1.7	Integrate Retrieval and Pretreatm		200			1,700
1.2.2.1	Calcine Waste	2,808	500			10,138
1.2.2.3	Prepare Retrieved Waste for Tra	1,000	1,700			5,234
1.2.2.4	Clarify Liquid Stream		400			5,255
1.2.2.5	Remove Radionuclides		4,500			29,004
1.2.2.7	Process Sludge		2,400			13,737
1.2.2.8	Prepare Pretreated Waste for Im		1,400			4,700
1.2.3.1.1	Monitor and Control LLW Imm	250	1,600			5,518
1.2.3.1.3	Immobilize LLW Stream	1,125	2,350			10,656
1.2.3.2.1	Monitor and Control HLW Imm		600			1,200
1.2.3.2.2	Prepare Secondary Waste from I					2,955
1.2.3.2.3	Prepare Sludge Feed	50	200			5,507
1.2.3.2.4	Immobilize HLW Stream		2,500			8,343
1.2.3.2.5	Treat HLW Offgas					550
1.3.1.3	Define Closure Criteria					5,185
1.3.1.7	Stabilize Tank for Closure		1,000			2,300
	TOTALS	10,983	35,950			219,755

(a) Bases for funding estimates: Estimates were provided by

(b) EM-50XC = EM-50 crosscutting programs (Efficient Sep

Section 4 - Programmatic Strategy

The objective of the TFA is to build a risk-driven, fully integrated, fully leveraged technology development program that is responsive to user and stakeholder needs for the remediation of high-level radioactive waste tanks.

In this section, the strategic intent of the program, as well as the implementation and management strategies for achieving this objective are presented and discussed. For reference, the conceptual model used to illustrate this strategy is shown in Figure 4.1.

4.1 Strategic Intent of the TFA Program

The TFA is risk driven - The only reason to invest in technology development activities is to reduce the risks associated with cleanup. These include the environmental, safety, and health risks to both workers and the public; cost and schedule risks; programmatic risks; and technical risks. The strategic intent of the TFA is to work closely with the Office of Science and Technology's Risk Program, the tank site user programs, and STCGs to develop a risk-based prioritization of needs, and to make technology investments in response to those needs.

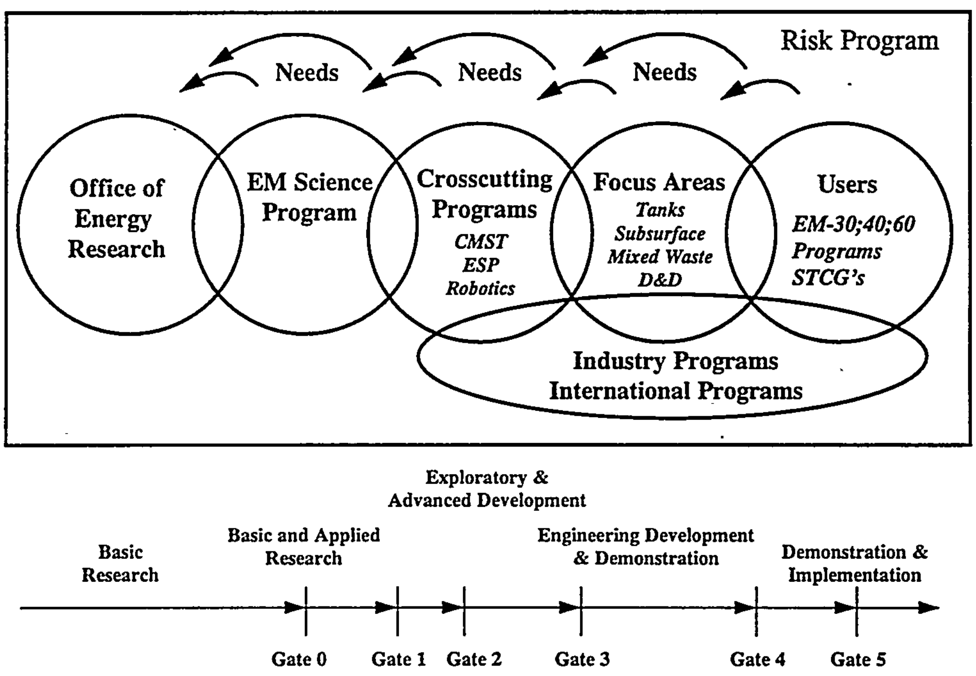

Figure 4.1. TFA Conceptual Strategy Model

The TFA is fully integrated - The TFA is organized around problem elements, which describe site technical needs, and not individual unit operations. Moreover, these problem elements are designed to achieve the greatest multisite benefit from the resulting technology investments. The strategic intent of the TFA is to develop technology for integrated multisite systems solutions (see Section 4.3).

The TFA is fully leveraged - In the model illustrated in Figure 4.1, each element in the technology maturation cycle (see Section 4.2) is linked to the elements on either side and to the DOE's industrial and international outreach programs. Moreover, the "downstream" programs are the customers for the "upstream" programs. For example, the users are the customers for the focus areas, while the focus areas are the customers for the crosscutting programs. Needs flow upstream from the user, while technology solutions flow downstream to the user. The strategic intent of the TFA is to leverage every available science and technology investment made by DOE and in doing so, engage the entire intellectual capacity of the nation in solving this problem (see Section 4.4).

The TFA is responsive to user needs - In addition to the development of a risk-based prioritization of user needs as discussed above, the strategic intent of the TFA is to work in partnership with site users and stakeholders (through STCGs) to ensure the implementation of technology investments (see Section 4.3).

4.2 Managing Technology Development

During FY96, the TFA developed a program vision called the "right program." Two important concepts helped form this vision. First, as described in Section 2, the "right program" began with the analysis of site-provided needs and the development of an annual program responding to needs defined as having high-impact risk-reduction potential. Secondly, the reduction of inherited (mortgaged) tasks allowed the TFA more flexibility in meeting those needs. A benefit of this flexibility is a broader, longer-term technical planning horizon. As a result, this MYPP reflects the results of planning efforts that considered many more technical implications and task interrelationships than previously demonstrated.

This year, the TFA has also implemented the staged-gate approach (see Figure 4.1) to managing the progress of technologies from development through deployment. In this framework, specific criteria exist for a technology to progress from one technology maturation level (or "stage") to the next by passing through a "gate." These gate criteria focus decision-making, foster early user-involvement, and provide decision and review points. Table 4.1 shows the technology maturation levels of the TFA technical activities proposed for funding in FY97.

As is clear from Table 4.1, the TFA funds no activities within the basic and applied research levels. However, these activities have enormous risk reduction potential if successful and should be supported by the relevant DOE programs, as shown in Figure 4.1. A more complete discussion of the coordination and leveraging of science and technology investments is given in Section 4.4.

Table 4.1. Technology Maturity Levels for FY97 TFA Technical Activities

Technology Level	Exploratory Development	Advanced Development	Engineering Development	Demonstration	Implementation
Technical Activity			• Steel Tank Corrosion Prevention Technology • Waste Acceptance Testing • Cold Cap/Offgas Chemistry • Characterization & Retrieval Process .Deployment • Simulant for Retrieval Testing • Russian Sludge Retrieval Equipment • Caustic Recycle • Enhanced Sludge Washing • Enhanced Sludge Washing Analysis • Sludge Treatment Chemistry • Alternative Alkaline Washes • Monitor for Calcine Waste Process • Retrieval Process Analysis Tool • $NO_3/NO_2/OH$ Monitor • Thermal Denitration • Sludge Partitioning Chemistry • Optimize Waste Loading • Technetium Removal Flow Studies • HTI - Waste Conditioning Requirements for Heel Transfer • Corrosion of Melter Materials	• Sludge Treatment Equipment Demonstration • Grout Waste Forms for ORR • Glass Waste Forms for ORR • Pretreatment Process Analysis Tool • Ultrasonic Particle Monitor • Crossflow Filtration • Radiochemical Removal by Chemical Extraction for INEL • Technetium Removal Flow Studies • Countercurrent Decanting • HTI - Characterization of Hanford Tank 106-C Heel • HTI - Heel Retrieval Hanford Tank 106-C • HTI - HTI Demo Ops. Safety, Risk Support • HTI - ERT • HTI - On-Line Slurry Monitor • Pulsed Air System • CSEE for INEL • Cone Penetrometer/Raman • Laser ablation/mass spectrometer	• LDUA Supervisory Control • LDUA Deployment - ORR • LDUA System • Immobilization of Ion-Exchange Resins • Industrial Spt for First Deploy of Retrieval Systems • WR&C Demo for Salt Removal & Zeolite • Enhanced Retrieval Technology • Cesium Removal • Cesium Removal - CST • SRS Closure Criteria • HTI - Deploy for Characterization and Closure of Hanford Tank 104-AX • HTI - Characterization of Vadose Zone Around Hanford Tank 104-AX • HTI - Hanford Tank 104-AX Retrieval Performance Criteria
Gate	*2*	*3*	*4*	*5*	*6*
Criteria to State	• *Address DOE need Enter Technology* • *Indicate complementary or redundant efforts*	• *Address focus area need* • *Identify/address feasibility* • *Identify user needs/wants* • *Competitive product analysis* • *Identify ES&H issues* • *Identify stake-holder 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 permits for demonstration*	• *EM-30/EM-40 procures technology* • *Public acceptance* • *National Environmental Policy Act permits for deployment*

CSEE	Confined Sluicing End Effector	ES&H	environmental, safety, and health	ORR	Oak Ridge Reservation
CST	crystalline silicotitanate	HTI	Hanford Tanks Initiative	SRS	Savannah River Site
DOE	U.S. Department of Energy	INEL	Idaho National Engineering Laboratory	WR&C	waste retrieval and closure
ERT	Electrical Resistance Tomography	LDUA	Light-Duty Utility Arm.		

The use of technology maturity levels permits logical management of limited resources where promising technologies pass through "gates" from stage to stage. 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 of the gate criteria from basic research through demonstration.

Table 4.1 presents a comprehensive view of the TFA recommended program in terms of the stages and gates a technology must pass through before implementation. Because the maturity of each technical activity 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 can 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 FY97 work plan.

Passing through a gate marks an important technology milestone. A typical TFA-funded activity represents a technology characteristic of exploratory development or beyond. Nevertheless, 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. Therefore, while the TFA normally adopts technologies in the later maturity levels, earlier gate criteria serve as critical checkpoints that still must be met.

Gate 4 is a main gate 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.

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

The TFA recognizes more work must be done to fully benefit from technology maturity level management. During FY96, the TFA initiated its introduction into management of technical activities using the technology maturity levels concept. Technology groupings, or technical elements consisting of one or more individual technologies, were categorized into a maturity level. With an improved understanding of maturity levels and gating criteria gained in FY96, the TFA's FY97-99 program properly reflects increased maturity level management at the technical activity level. In the next year, the TFA intends to increase its emphasis on technology maturity levels.

4.3 Site Deployment Strategy

A TFA mission objective is the integration of technologies for multisite benefit. The TFA takes great care in collecting and analyzing site needs and matching technical solutions to them. For each problem element proposed for funding, the TFA identified the primary and secondary benefiting sites. This is portrayed in Table 4.2. Sites receiving primary benefit are indicated by a dark-shaded box, and secondary benefit sites are indicated by a lighter-shaded box. A blank box has two 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 problem element. This vision continues to be a major strategic challenge, requiring a combination of general strategies 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 and memorandums of understanding will formalize the TFA's commitment to user, producer, and developer partnerships across sites regarding test variables and results that must be obtained to meet multisite requirements and ensure technology implementation.

4.4 Coordinating and Leveraging Technology

The EM currently funds approximately $62 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 technical task packages or activity data sheets 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 risk-reduction needs in the *TFA FY 1996 Site Needs Data Assessment* (TFA 1996) and the program in this MYPP to identify high-impact, risk-reduction 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.

The TFA envisions that in FY97 it will manage (have responsibility for scope, schedule, and budget) the Office of Science and Technology's tanks program described in this MYPP, along with some Hanford Tank Waste Remediation System technology development activities (including, but not limited to, activities related to the MYPP scope). The TFA will coordinate work conducted by the Office of Science and Technology crosscutting programs that is related to tanks as well as related work being conducted by other focus areas and by each of the site's EM-30 or EM-40 programs. By FY98, the TFA envisions greater management of 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

Table 4.2. Site Implementation Strategy of Problem Elements

Problem Element	Site Implementation Strategy			
	Hanford	INEL	ORR	SRS
1.1.1.1 Monitor Tank Integrity	□	■	□	■
1.1.1.2 Avoid Tank Corrosion	■	□	■	■
1.1.3.1 Characterize Waste In Situ	■	■	□	□
1.1.3.2 Sample Waste	■	□	□	□
1.1.3.3 Analyze Waste	■	□	□	□
1.1.4.2 Reduce Recycle Streams	□	□	□	■
1.2.1.1 Deploy Equipment	■	■	■	■
1.2.1.2 Mobilize Bulk and Heel Wastes	■	■	■	■
1.2.1.5 Detect and Mitigate Leaks	■	□	■	■
1.2.1.6 Monitor and Control Retrieval Process	■	□	■	□
1.2.1.7 Integrate Retrieval & Pretreatment Tech Systems	■	□	■	□
1.2.2.1 Calcine Waste	□	■	□	□
1.2.2.3 Prepare Retrieved Waste for Transfer and Pretreatment	■	■	■	■
1.2.2.4 Clarify Liquid Stream	■	■	■	■
1.2.2.5 Remove Radionuclide	■	■	■	■
1.2.2.7 Process Sludge	■	■	■	■
1.2.2.8 Prepare Pretreated Waste for Immobilization	■	□	□	■
1.2.3.1.1 Monitor and Control LLW Immobilization Process	■	□	□	□
1.2.3.1.3 Immobilize LLW Stream	□	■	■	■
1.2.3.2.1 Monitor and Control HLW Immobilization Process	■	□	□	■
1.2.3.2.2 Prepare Secondary Waste from Pretreatment	■	□	■	□
1.2.3.2.3 Prepare Sludge Feed	□	□	□	■
1.2.3.2.4 Immobilize HLW Stream	■	■	■	■
1.2.3.2.5 Treat HLW Offgas	■	□	□	■
1.3.1.3 Define Closure Criteria	■	■	■	■
1.3.1.7 Stabilize Tank for Closure	■	□	□	□

Legend: Primary benefiting site ■

Secondary benefiting site □

Problem not applicable to or already resolved at site 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.

The strategy for developing leveraged or coordinated activities is presented in Sections 4.4.1 through 4.4.5.

4.4.1 Other Focus Areas and Crosscutting Programs

The TFA goal is to extensively leverage the activities in the other focus areas -- Subsurface Contaminants; Mixed Waste; and Decontamination and Decommissioning -- and the Office of Science and Technology's Crosscutting Programs -- Efficient Separations and Processing; Characterization, Monitoring and Sensor Technology; and Robotics. Most importantly, the TFA is the customer for tank technologies developed in these, facilitating their transition, in the staged-gate framework, from development to implementation.

Significant resources exist in the other focus areas and crosscutting programs that can contribute significantly to the development of innovative tank remediation technologies. Moreover, these programs can help to bridge the work sponsored by the EM Science Program and the TFA.

Achieving these goals requires joint, timely planning between programs in the following four areas.

- *Program Scope Boundaries* - The TFA and focus area/crosscutting program's technical team leadership define technical scope boundaries between programs to ensure minimum overlap of work scope and maximum leverage of resources.

- *Program Definition* - The TFA and focus area/crosscutting program's technical team leadership participate in the definition of specific technical program work scope, through activities such as joint proposal selection, to ensure proper coordination and the smooth transition of relevant scope, using the staged-gate framework, from the focus area/crosscutting program to the TFA at the appropriate time.

- *Program Execution* - The TFA and focus area/crosscutting program's technical leadership facilitate the coordination of relevant technical tasks, ensuring that principal investigators have the necessary resources for sharing the results of their research and development. In addition, the TFA can facilitate the interaction between focus area/crosscutting program's principal investigators and the cognizant technical staff of the users.

- *Program Review* - The TFA and focus area/crosscutting program's technical leadership participate in the technical peer review of program technical activities, ensuring that the relevant technical activities are appropriately focused and making progress towards implementation.

This implementation path for this strategic intent, which has been realized to various extents in FY96, is described below.

- *Program Scope Boundaries Implementation Path* - The TFA Strategic Initiative Coordinator and Program Coordinator for focus area/crosscutting programs will work to define appropriate technical work scope boundaries.

- *Program Definition Implementation Path* - The TFA Strategic Initiative Coordinator, Technical Integration Coordinator, and appropriate Technology Integration Managers participate with the Program Coordinator for focus area/crosscutting programs in the screening and review of proposals for crosscutting program definition. Likewise, the Crosscutting Program Coordinators participate in the screening and review of proposals resulting from joint calls for proposals. Finally, the TFA Strategic Initiative Coordinator and Program Coordinator for focus area/crosscutting programs will target crosscutting program tasks relevant to the TFA and assist the principal investigators in developing action plans for evaluation and, if appropriate, transfer of work scope to the TFA.

- *Program Execution Implementation Path* - As a result of joint calls for proposals, the TFA and focus area/crosscutting programs may jointly fund technical activities. The coordination of these and other appropriate technical tasks is the responsibility of the TFA Technical Integration Coordinator, appropriate Technology Integration Managers, and relevant Program Coordinator for focus area/crosscutting programs.

- *Program Review Implementation Path* - The TFA Strategic Initiative Coordinator, Technical Integration Coordinator, and Technology Integration Managers (as appropriate) will participate as full members of the focus area/crosscutting program's technical review group. Likewise, the Program Coordinator for focus area/crosscutting programs will participate as a full member of the TFA review group.

Significant barriers to the implementation of this leveraging strategy exist and must be continually challenged:

- *Program Scope Boundaries Barriers* - Currently, the role and mission of the crosscutting programs relative to the EM Science Program and the focus areas are ill-defined. There is no overall understanding of, or guidance for determining, how these programs should interact. Moreover, the timing of the current system of program development (e.g., program execution guidance) does not allow for this kind of interaction.

- *Program Definition Barriers* - Each of the focus area/crosscutting programs determine their scope boundaries, and hence define their programs, very differently.

- *Program Execution Barriers* - There is a need to formalize the concept of the TFA as one customer for dual-use technologies developed in other focus areas, and the customer crosscutting. program technologies through the development and implementation of action plans for the transfer of tank-related focus area/crosscutting program technologies to the TFA at the appropriate time.

- *Program Review Barriers* - This interaction also needs to be formalized and generalized to all of the focus area/crosscutting programs.

4.4.2 Industry and Industrial Programs

The goal is to have 30% of the TFA investment in tank technology development and demonstration devoted to significant industrial participation by FY98. The purpose for such a strategy is to ensure goods and services are available in time to support the development, production, and implementation of the technical solutions provided by the TFA to meet key user needs. The funding for these activities will come from both the TFA and Office of Science and Technology's Industry Programs.

As discussed in Section 4.2, the TFA is committed to using the staged gate approach, with explicit go/no go gate decision criteria, as a guide for implementing this strategy. However, some TFA technology development activities provide information required for technical and programmatic decisions to be made and are, therefore, not compatible with focused industry decision criteria. These activities are evaluated on a case-by-case basis for exemption from this strategy. The strategic intent of the TFA is to have industry participate in all aspects of the user, producer, and developer team:

- *Industry as User* - The TFA will be opportunistic, facilitating the involvement of industry as a technology user on a case-by-case basis.

- *Industry as Producer* - The TFA will follow a policy of "buy first" for all technologies at engineering development (Stage 4) or higher. All producers of technology higher than Stage 4 will be industry unless exempted by the TFA.

- *Industry as Developer* - The TFA will encourage, as extensively as possible, partnering between industry, national laboratories, and universities for all technology development activities below Stage 4.

The TFA will use a phased implementation approach, with many of the elements of this strategy operational in FY97. The strategy will be fully operational in FY98.

- *Industry as User* - The identification of opportunities for users, producers, and developers to interact will result from the development and execution of technology business action plans (see Industry as Producer below). In these instances, the TFA will work to facilitate this interaction to speed the implementation of TFA-developed technology (FY97).

- *Industry as Producer* - The TFA will

  - require an actively involved industrial partner, capable of producing material and/or equipment for all demonstrations at Stage 4 or higher (FY98)

  - require the development of business action plans for all technologies at exploratory development (Stage 2) and advanced development (Stage 3) (FY97)

  - support principal investigators in the identification of partners for demonstrations (FY97).

- *Industry as Developer* - The TFA will evaluate potential responses to new technology needs (FY98).

  - For potential responses at Stage 4 or higher, the first call will be to industry, with a subsequent call to national laboratories and universities should no developer be identified.

  - For potential responses at Stage 3-4, a call will be issued to national laboratories and universities requiring a business/industrial partner for successful awards.

  - For potential responses at Stage 1-2, a call will be issued to national laboratories and universities encouraging the inclusion of a business/industrial partner.

The identification of which stage a potential response is at will be an integral part of the needs identification and prioritization process. General criteria for assessing the potential responses will be developed by the TFA Technical Team, which will assess the response against the criteria. The results will be validated by the USG.

Significant barriers to industrial participation exist and must be continually challenged.

- *Industry as User Barriers* - The current environmental, safety, and health and regulatory issues associated with accessing high-level radioactive waste tanks requires that DOE maintain significant control and oversight of implementation scenarios. This results in limited markets for industrial users; makes the user, producer, and developer coupling more difficult, increasing cost, and inhibiting producers from entering the market.

- *Industry as Producer* - The market for tank technologies is small due to the absence or limit to the dual use potential of tank technologies, as well as the limited quantities required for cleanup. This drives the TFA to specialty companies operating in niche markets, which typically increases cost; or may result in the inability of the TFA to identify a suitable partner.

- *Industry as Developer*

  - Limited market potential (as return on investment) and the perception of high investment risk (compared to other technology markets) for tank technologies results in limited capital formation to support tank technology business/industry partnerships.

- ES&H and regulatory concerns make access to high-level radioactive waste, waste tanks, and radioactive facilities difficult and expensive. This inhibits the ability of industry to demonstrate developed technologies.

- Once development is completed, time to implementation is potentially measured in decades, further eroding return on investment. An up side to this is that the market length (this is a 30- to 50-year problem) can be attractive to small firms seeking to establish a steady market share.

4.4.3 International Programs

Our strategic intent for international programs is the opportunistic leveraging and coordination of DOE's investments. This is accomplished via joint definition of scope between the TFA and the international performers based upon the overlap between the user-defined and validated needs and the particular expertise of the performer. For FY96, the TFA has several projects with AEA Technologies (England) and Russia.

4.4.4 EM Science Program

The linkage of DOE's full complement of science and technology resources is critical to addressing problems of national significance in waste management and minimization, and environmental remediation. The EM Science Program is one vehicle for achieving the integration of science into DOE's technology development efforts. Acceleration of the technology development cycle through the integration of science can be done by creating multidisciplinary "technology fusion" teams that will deliver timely solutions to both the short- and long-term environmental problems faced by DOE. The strategic intent of the TFA is to develop strong programmatic and technical linkages between the EM Science Program and the Office of Science and Technology's technology development programs as illustrated in Figure 4.1.

To initiate this linkage, the TFA developed an outline of key scientific problems that if solved would result in a high payoff on our technology investments, and provided this information as input to the development of the FY96 EM Science Program call for proposals.

In FY97 and future years, the EM Science Program will develop its calls for proposals based upon site-specific science needs input that is developed by STCGs. The TFA, through its technology needs collection process, is working with the sites to contribute to the development of site-specific science needs that are clearly driven by the users' problems. This ensures that work is done on the most critical, high-impact problems and, that if successful, there is a way to advance their success through the technology maturation cycle, as illustrated in Figure 4.1.

Significant barriers to this exist and must be continually challenged

- The EM Science Program is a new program that is to be "co-managed" by the Office of Energy Research and the EM, organizations with very different values and cultures.

- The current EM Science Program execution model funds individual researchers across the nation. This makes it enormously difficult, if not impossible, to develop and direct an integrated effort aimed at the most intractable problems.

- The current EM Science Program execution model funds individual researchers in both the national laboratories and universities from separate sources of money making the integration of university and national laboratory researchers (who are closer to the issues facing site users and stakeholders) difficult.

4.4.5 Office of Energy Research

The total budget of the EM Science Program is small compared to overall basic research expenditures made by DOE's Office of Energy Research. The strategic intent of the TFA is to use the EM Science Program to educate the fundamental research community of the nation to the difficult and exciting technical challenges faced by tank cleanup and, by doing so, influence the basic research agenda of DOE to complete the integration of all stages in the technology maturation life cycle, illustrated in Figure 4.1.

4.5 Alternative Tank Remediation Scenarios

The TFA technology investment portfolio is driven by user and stakeholder needs. These needs are developed in response to the DOE baseline strategies for tank remediation at the four tank sites - namely waste retrieval followed by waste processing that results in a low-activity waste that is disposed onsite and a high-activity waste that is stored on site until completion of the repository. The programmatic and technical strategies described in this document respond to this remediation scenario, but also can be used to meet alternative scenarios that could arise between now and FY00. If there are shifts in the baseline strategies, the technology investment portfolio would be adjusted through a combination of the following:

- continuation of ongoing tasks as currently scheduled

- acceleration of ongoing tasks

- refocusing ongoing tasks

- development of new scope.

The alternative scenarios that are currently on the horizon include privatization, mortgage reduction, and environmental, safety, and health risk reduction. The corresponding changes in the technology investments for each of these potential scenarios is summarized in this section along with a description of the process for making the appropriate program adjustments.

4.5.1 Privatization

DOE is moving toward privatization as an alternative approach to remediating tanks and tank waste. The underlying strategy would be the same; it is the performers of the waste processing to meet this strategy that would differ. Recently a proposal for privatizing treatment of M Area sludges at the SRS was selected. The Hanford Site is in the midst of a proposal review for phase Ia and Ib of privatization in which supernate treatment and LLW processing will be conducted (1a), with the option of HLW processing (1b). Phase II privatization at Hanford will include retrieval and immobilization of HLW as well as the supernate processing. Privatization for the Melton Valley Storage Tanks at ORR is also being considered.

There are two primary impacts of privatization to the technology development program. First, the technology user will be different. Today, the user is the site field office and management and operations contractor. Under privatization, technology would be selected by the private contractor to meet DOE performance objectives. For the TFA, this change means that the user input to developing needs shifts to a new contractor.

The second aspect of privatization that effects TFA technology investments centers on the issue of experience with DOE waste types. Part of the purpose for moving to a privatization scheme is to maximize use of industrial experience on a DOE problem, hopefully to meet schedules at reduced costs. However, the bulk of industrial experience with nuclear materials is with acid-side processing. Hence, some aspects of alkaline processing, especially processes for the broad envelop of Hanford Site waste conditions, will have elements of first-of-a-kind processing.

The TFA has, and is, making technology investments to provide additional information on the different ORR and Hanford waste types available to support successful implementation of privatization. At ORR, the use of out-of-tank evaporation, cesium removal processing units, and LLW form comparison work should provide DOE Oak Ridge Operations Office with critical data for evaluating privatization proposals and vendors. At Hanford, the FY97 work described in Section 3.3 is directed at supporting phase I and II privatization. The supernate, solid-liquid separation, and LLW immobilization work is specific to phase I issues. The retrieval systems, retrieval and pretreatment interface issues, sludge processing, and HLW immobilization work is directed to phase II issues.

Consequently, the scope of work identified in Section 3.3 would be continued as defined to support privatization at Hanford and ORR. The SRS already has the experience it needs to successfully implement its privatization of M Area sludge processing.

4.5.2 Mortgage Reduction

A key aspect of mortgage reduction is reducing operating costs. These costs can be reduced for every tank or tank farm that is closed. TFA is focusing its technology investments in identifying those conditions under which DOE, regulators, and stakeholders will consider a tank or a portion of a tank farm ready for closure.

As a result, those activities identified primarily in Problem Elements 1.3.1.3 Define Closure Criteria, and 1.3.1.7 Stabilize Tank for Closure would continue to have strong emphasis. It would be anticipated that work scope in these areas would be accelerated under a mortgage reduction scenario.

4.5.3 Environmental, Safety, and Health Risk Reduction

A key aspect of a scenario in which environmental, safety, and health risk reduction becomes paramount would be the ability to rapidly process tanks that have the highest risk. At the SRS, the Defense Waste Processing Facility is in operation so that no change to processing would be anticipated. At INEL, the need to calcine waste for interim storage would be emphasized. The TFA is currently investing in technology to support the alternative calcination process. This work could be accelerated if needed to meet risk reduction requirements. At ORR, compact processing units can be used to process waste at tanks without building large, new facilities. The TFA has already provided the out-of-tank evaporator and will be providing the cesium removal units in FY97. In addition, a glass or grout facility is also being prepared through the TFA to handle LLW immobilization by FY98.

At Hanford, the TFA would emphasize deployment of compact processing units for clarification of liquids, radionuclide removal, sludge processing, and waste immobilization. The underlying process chemistry for pretreatment would still be required. Hence, technology development described in Section 3.3 which is directed at Hanford needs would continue, but would be slightly refocused to emphasize the specific waste types of a high risk tank. In addition, there would to be an acceleration of the compact processing unit concept to deploy this process chemistry at Hanford. The enhanced mixing and retrieval technology development would be refocused to emphasize just-in-time retrieval techniques that would allow a single tank or small groups of tanks to be processed at rates consistent with compact processing units. The work on the immobilization process would be refocused to consider processing scenarios on a tank-by-tank basis or for small groups of tanks.

A potential added advantage to using the compact processing unit concept at Hanford is the reduction in immediate capital investments for a large facility and a reduction in the annual operating costs, i.e., a smaller, standing labor force is needed to operate a compact processing unit. Although life-cycle costs for smaller individual units may be higher based on user estimates to date, the cost distribution is more even which is important in times of constrained budgets and the ability to get high risk waste processed more rapidly is advantageous.

A second aspect of environmental, safety, and health risk reduction is assuring the stakeholders that key risk issues have been identified and are being addressed. To accomplish this, characterization technology is needed to describe the tank integrity and waste composition. Therefore, the technology strategies and investments associated with Problem Elements 1.1.1 Extend Tank Life, and 1.1.3 Characterize Tank Waste would be accelerated to meet any changes in user schedules.

4.5.4 Development of Technology Investment Portfolio with Changing Approaches and Strategies

It is very likely that the TFA strategies and investment portfolio will be influenced by all three alternative scenarios discussed. In the face of severe budget constraints, there are also issues associated with technology investments to reduce life-cycle costs.

The balance of investments needs to be systematically evaluated. The technical approach taken by the TFA to make this evaluation is development of a strategic decision analysis tool. This work was initiated in FY96, using a dramatic cut in budget as the first assumption. In the future, the tool will be expanded to look at assumptions about risk and mortgage reduction, and be used to guide investments as the package is completed.

Section 5 - References

Tanks Focus Area (TFA). 1996. *TFA FY 1996 Site Needs Assessment.* PNL-11091, Pacific Northwest National Laboratory, Richland, Washington.

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Appendix A - Description of DOE's System for Remediating Tank Waste

The U.S. Department of Energy (DOE) stores radioactive waste in tanks at Hanford Site, Washington; Idaho National Engineering Laboratory (INEL), Idaho; Oak Ridge Reservation, Tennessee; and Savannah River Site (SRS), South Carolina. The cleanup of the tank wastes will be very costly and time consuming, especially given the high activity level of the waste. Waste tank cleanup at these sites will cost an estimated $55 billion in constant 1996 dollars (DOE 1996). In addition, resulting health and safety risks to workers, the public, and the environment from cleanup exist that must be reduced to the greatest extent possible.

The Tanks Focus Area seeks to select user-driven solutions that reduce cost and risk and resolve regulatory and technical uncertainties. To support this goal, the technical program recommended in this multiyear program plan is based on assessment of the needs and qualitative judgments of the relative costs and risks of tank remediation across the DOE complex.

This appendix describes the currently available site baselines and the technical, cost, and risk data that underlie Tanks Focus Area's program recommendations. Section A.1 reviews the tank remediation systems at Hanford Site, INEL, Oak Ridge Reservation, and SRS, including tank waste remediation strategies, and lists estimated costs and schedules for tank waste remediation in constant 1996 dollars. Section A.2 reviews system risks. Section A.3 reviews stakeholder involvement and issues at each site. Section A.4 reviews the Tank Focus Area technical response and important considerations for planning purposes. Section A.5 discusses future steps. Section A.6 lists the references used.

A.1 Review of High-Level Waste Tank Programs

The tank waste remediation programs at Hanford Site, INEL, Oak Ridge Reservation, and SRS are briefly discussed in this section. The review describes the topography, hydrology, and meteorology at each site because these parameters tend to drive public health and safety concerns. The tanks and associated wastes at each site are briefly characterized, and the strategy for remediating tank wastes is described.

A.1.1 Hanford Site Overview

The federal government acquired the Hanford Site in 1943. For the first 45 years, the Site's primary mission was to produce plutonium for national defense and manage the resulting waste. In 1989, all production facilities were shut down and the mission has diversified to include technology development, waste management, and environmental restoration. The Hanford Site was placed on the National Priorities List under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). There are several major facility areas requiring cleanup: 100 Areas, 200 Areas, 300 Area, 400 Area, 700 Area, 1100 Area, and 3000 Area (DOE 1995a). Hanford tank farms are located in the 200 East and 200 West Areas (see Figure A.1). In addition to cleaning up tanks, problems include cleaning up or containing billions of liters of liquids discharged to the soil, decommissioning and decontaminating nine production reactors and hundreds of process-related facilities, disposing of stored solid wastes, and removing spent fuel from basins in the 100 Area.

The Hanford Site is briefly described below.

- The Hanford Site occupies 1,450 km^2 (560 mi^2) of a shrub-steppe ecosystem in southeastern Washington State. The Site and surrounding land is semiarid. The Site contains archaeological sites for Native Americans that date back more than 18,000 years.

- The Columbia River, which runs through the Hanford Site, drains the aquifer that lies under the tank farms in the 200 Areas. Contaminant plumes originating in the 200 East Area have reached the Columbia River (Kincaid et al. 1994).

- Currently, hazardous chemicals and radionuclides (nitrates, iodine-129, tritium, cesium-137, plutonium isotopes, technetium-99, and strontium-90) are present at levels that exceed Federal Drinking Water Standards in the groundwater beneath the 200 Areas and in plumes emanating from the groundwater that are moving towards the Columbia River (Dresel et al. 1994).

- 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).

- The rate at which moisture released to the soil eventually reaches the groundwater (recharge rate) below the Hanford Site varies from 5 to 10 cm/yr (2 to 4 in./yr) depending on the amount of precipitation and vegetative cover (i.e., use of barriers reduces the recharge rate to less that 0.1 cm/yr) (Wood et al. 1995).

- The depth to groundwater 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. In comparison to groundwater depths, tank depths vary from 11 to 17 m (37 to 57 ft).

- Prevailing winds in the area are from the west-northwest with the northwest and southwest being the next most common directions.

- The average wind speed is 3.6 m/s (7.9 mi/h). Wind gusts well above average occur in the summer.

- The annual precipitation is 16 cm (6.3 in.).

- The population within 80 km (50 mi) is approximately 370,000 (RL 1996a; DOE-ID 1995b, Appendix A).

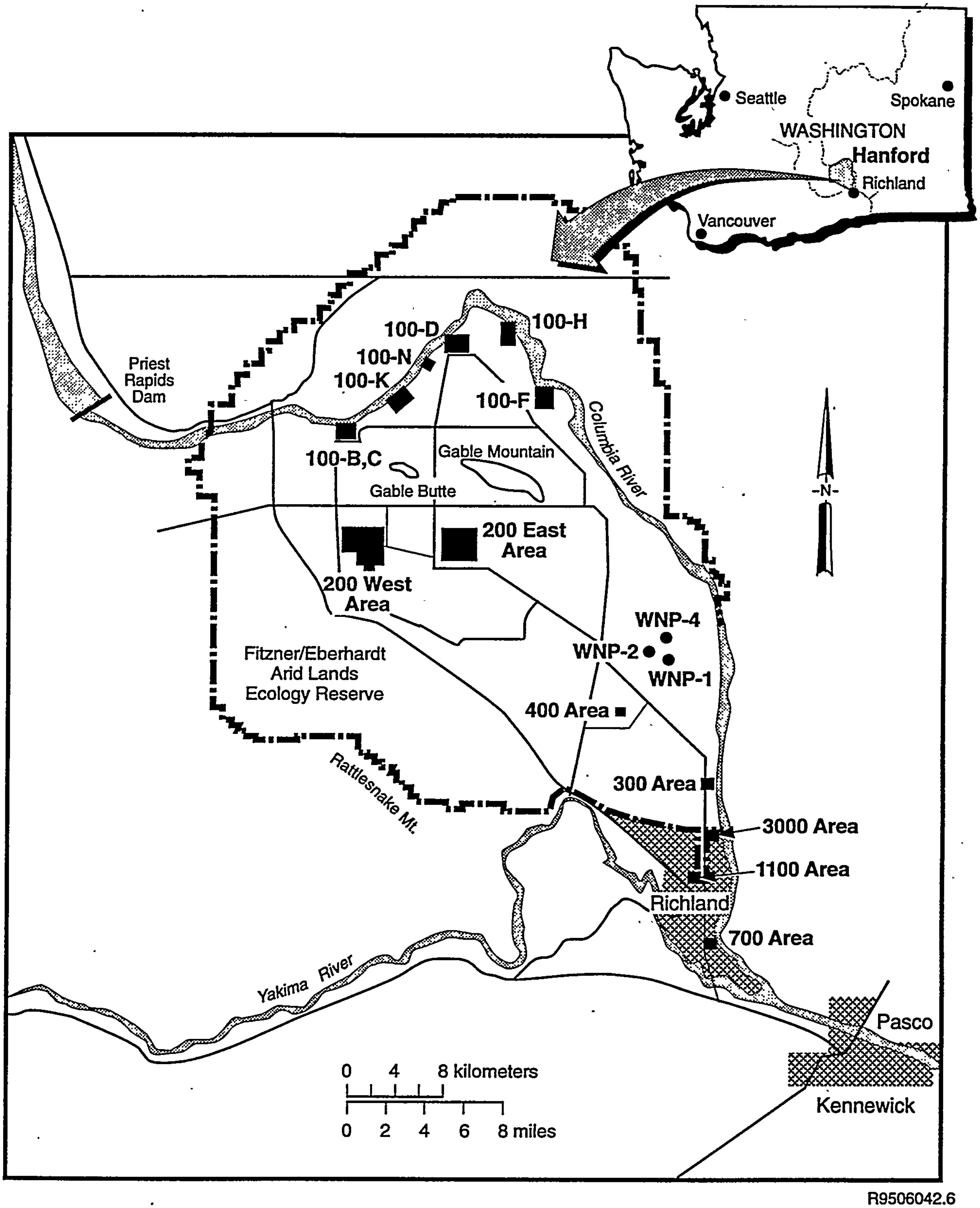


Figure A.1. Hanford Site and Major Facilities

A.1.1.1 Hanford Site Tanks

Wastes are currently stored in 177 underground tanks in the 200 Areas of the Hanford Site. There are 149 single-shell tanks and 28 double-shell tanks. The single-shell tanks, 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 million gal). Since 1956, 67 single-shell tanks have leaked or are suspected to have leaked. It is estimated that a total of 3.8 million L (1 million gal) of tank waste has leaked to the soil (Treat et al. 1995). All 149 single-shell tanks were removed from service as of November 21, 1980 and no longer receive any waste. The double-shell tanks were built from 1968 to 1986. The first double-shell tank was placed in service in 1971. Double-shell tanks consist of a carbon steel primary tank, an annular space, and a secondary steel tank encased in reinforced concrete. The nominal capacities range from 3,785 m^3 to 4,160 m^3 (1 million to 1.1 million gal). There is no evidence that any double-shell tanks have leaked, and all of the tanks are still in service.

Some of these tanks are subject to safety issues. Specific safety issues that must be addressed include radioactive exposures to both onsite and offsite personnel from a possible release of radioactive materials into the environment due to 1) ignition of flammable gases in tank head space, 2) propagating reactions of ferrocyanide-containing wastes, or 3) uncontrolled exothermic oxidation by nitrate or nitrite of high concentrations of mixed organic chemicals in tank waste. A certain level of moisture may need to be maintained in the tank waste to prevent hazardous conditions from evolving inside these tanks. There is also potential hazard from a structural failure if, in the event of a leak, cooling water additions are discontinued to Tank 106-C, a tank that generates high amounts of heat.

Besides the 177 tanks, there are miscellaneous underground storage tanks. The tanks contain waste that is similar to the waste in the double- and single-shell tanks, although in much smaller quantities. Active tanks are used as receiver tanks during waste transfer activities. Waste in these tanks is less than one-half of 1% of the total tank inventory at the Hanford Site (WHC 1995).

A.1.1.2 Hanford Site 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 208 million L (55 million gal) of wastes. Because of the various processes, the waste is found in a variety of layers. 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 single- to double-shell tanks.

All Hanford tanks contain high-level waste (HLW), the liquid, saltcake, and sludge in single-shell tanks and slurry in double-shell tanks consist of HLW, transuranic (TRU) waste, and low-level waste (LLW). The total activity of waste stored is estimated to be about 128.3 MCi in the tank solids and 70.1 MCi in the tank liquids. The principal activity of the waste comes from cesium-137 and strontium-90 and their decay products (barium-137m and yttrium-90). Strontium-90 is largely contained in the sludge, and cesium-137 is soluble and in the supernate. The radioactive contents of the Hanford Site tanks and the tanks at INEL and SRS are shown in Table A.1. The chemical constituents of the sludge are mostly precipitated sodium salts, heavy metals, and iron, aluminum, and other hydrated metal oxides. Saltcake is primarily sodium nitrate; and the supernatant contains large amounts of dissolved sodium salts, especially nitrates and nitrites.

Table A.1. Radioactive Content of Tank Wastes at Selected U.S. Department of Energy Sites (Curies)

Radionuclide	Hanford Tanks	INEL Tanks	INEL Calcine	SRS Tanks
^{3}H	NA			8.50E+04
^{14}C	4.58E+03			2.00E+01
^{90}Sr	6.10E+07	4.52E+05	1.16E+07	1.20E+08
^{90}Y	6.10E+07	4.52E+05	1.16E+07	1.20E+08
^{99}Tc	3.21E+04			2.30E+04
^{129}I	2.98E+01			3.70E+01
^{106}Ru		1.66E+03	1.04E+04	
^{106}Rh		1.66E+03	1.04E+04	
^{134}Cs		1.04E+04	1.43E+05	
^{135}Cs				
^{137}Cs	3.86E+07	5.33E+05	1.33E+07	1.20E+08
^{137m}Ba	3.66E+07	5.05E+05	1.26E+07	1.10E+08
^{151}Sm	1.07E+06			
^{144}Ce		9.27E+03	5.33E+04	
^{144}Pr		9.27E+03	5.33E+04	
^{147}Pm			1.94E+05	
^{154}Eu		3.46E+03	6.50E+04	
^{238}Pu	1.43E+03			1.70E+06
^{239}Pu	2.60E+04			3.60E+04
^{240}Pu	6.69E+03			1.70E+04
^{241}Pu	9.78E+04			7.90E+05
^{242}Pu	2.80E+01			2.80E+01
^{241}Am	1.04E+05			2.35E+04
^{242m}Am	6.28E+01			6.41E+01
^{232}Th				1.47E+00
^{233}U				1.08E+02
^{234}U				3.01E+01
^{237}Np				7.04E+01
^{244}Cm				2.60E+03
Total	1.99E+08	1.98E+06	4.96E+07	4.73E+08

Source: DOE 1995b.
Notes: **Shaded cells** denote contaminants that are nonsorbing (i.e., move at the rate of water through the vadose zone).
NA is not available.
Blank cells denote that the radionuclide is not contained in the waste.
INEL = Idaho National Engineering Laboratory.
SRS = Savannah River Site.

A.1.1.3 Hanford Site Regulatory Drivers

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

- *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994). This agreement between the U.S. Environmental Protection Agency Region X, the DOE, and the Washington State Department of Ecology established the requirements for meeting federal and state Resource Conservation and Recovery Act regulations. The *Hanford Federal Facility Agreement and Consent Order* was originally signed in 1989 and then amended in 1994. The amended agreement committed Hanford to retrieval of waste from the single-shell tanks, vitrification of LLW, cessation of the grout program, and National Environmental Policy Act coverage of actions. This agreement serves as the site treatment plan required under the Federal Facility Compliance Act of 1992 (PL 102-386).

- The *Hanford Federal Facility Agreement and Consent Order* 1966 Amendments (DOE and Ecology 1996b). A *Hanford Federal Facility Agreement and Consent Order* change package was submitted that recognizes DOE's plans for private financing and operation of the tank waste treatment facilities (Tank Waste Remediation System [TWRS] Privatization Request for Proposal No. DE-RP06-96RL13308 [DOE-RL 1996b]). The change will not affect major milestones for the processing of tank waste, except that low-activity wastes will be treated by 2024 instead of 2028.

- *Draft Environmental Impact Statement (EIS) for the Tank Waste Remediation System* (DOE and Ecology 1996a). The EIS provides 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, are evaluated. A record of decision for the TWRS EIS is planned in 1996.

- Hanford Site Land Use. DOE has begun developing a land use plan for Hanford to be included in the EIS for Hanford remedial actions. The EIS is to be released in 1996. The plan and the record of decision for the EIS will identify land uses and accompanying restrictions for major Site areas. The future land use currently assumed for the 200 Areas is industrial and/or commercial. This area will likely be held exclusively for disposal, containment, and management of waste, and other compatible uses. Access to the area and use of the groundwater is assumed to be restricted indefinitely.

- Project Hanford Management Contract Request for Proposals DE-RP06-96RL13200 (DOE-RL 1996a). This request for proposal is soliciting a contractor team to manage and integrate remediation of the Hanford Site. The request sets many near-term DOE-specified performance measures for tank waste disposal including designing a retrieval system by 2001, providing feed material to the low-activity waste immobilization facility by 2002, and constructing a low-activity waste interim storage facility by 2002. These performance objectives are not negotiable.

- Defense Nuclear Facilities Safety Board Recommendation 93-5 (DOE-RL 1994). The board issued 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. These deadlines have not been met.

- Nuclear Waste Policy Amendments Act of 1987 (42 USC 10101). This act designated the Yucca Mountain Site, Nevada, for detailed scientific investigations to evaluate the site's suitability for hosting a permanent geologic repository. Technical site suitability determination is planned in 1998, with submittal of a repository license application to the U.S. Nuclear Regulatory Commission in 2001 and the start of repository operations in 2010.

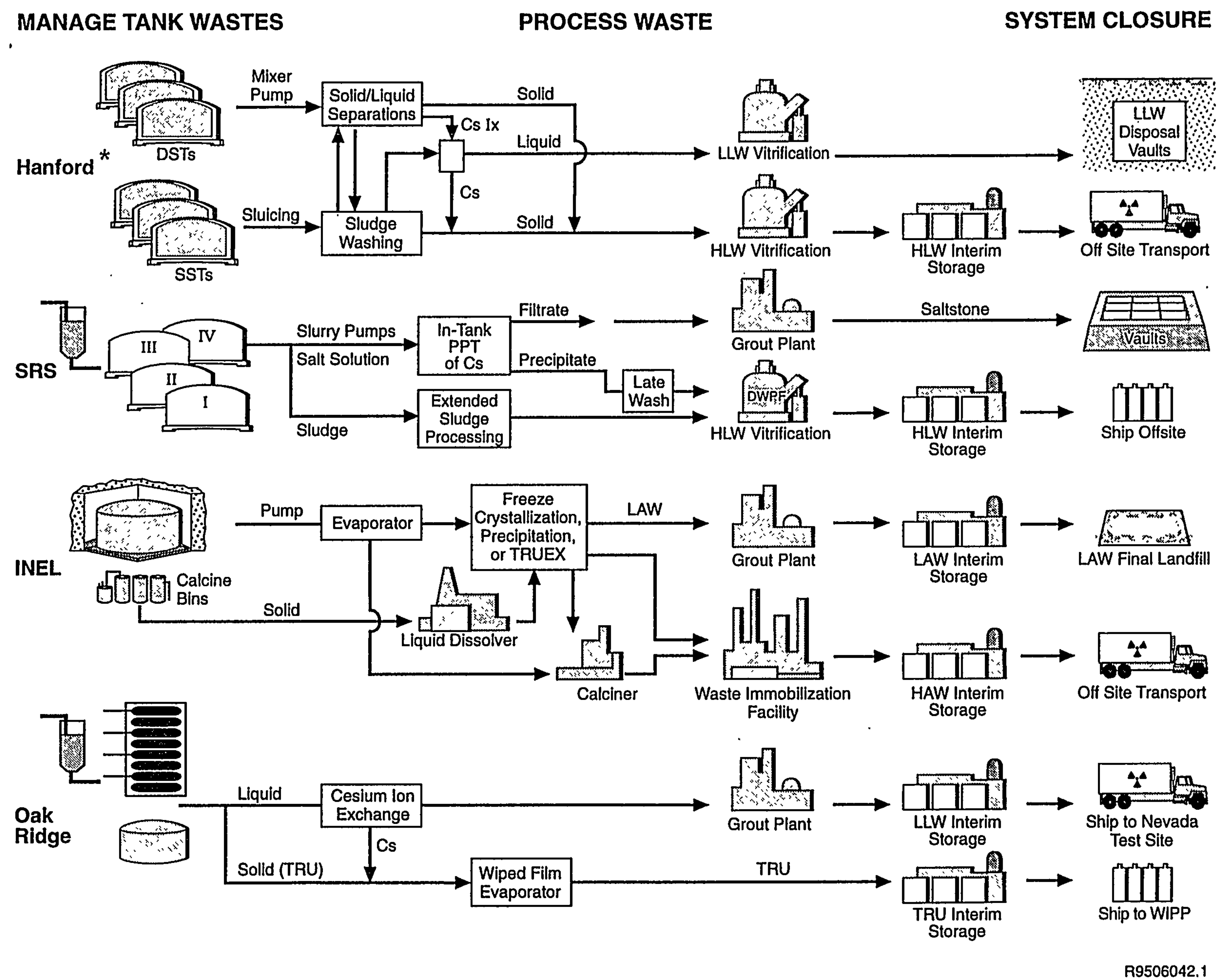
A.1.1.4 Hanford Site Remediation System Description

DOE established TWRS in 1991 to oversee 1) receiving, safely storing, maintaining, and treating existing tank waste; 2) interim storage of HLW; 3) packaging of HLW for offsite disposal; and 4) disposing of LLW in a retrievable form on the site. The TWRS program also supports maintaining, operating, and upgrading existing facilities, such as waste storage tanks, evaporators, and pipelines. Tank Focus Area supports the TWRS program by developing the technologies to accomplish TWRS' mission objectives.

The TWRS strategy is illustrated in Figure A.2. Well-known hydraulic sluicing methods will be used to retrieve single-shell tank wastes, and mixer pumps will be used to retrieve double-shell tank wastes. A substantial amount of secondary waste will be generated as retrieval equipment is contaminated and obstructions (solid waste, old equipment) are removed from the tanks.

If privatization is successful, private companies will design and operate the TWRS facilities that will pretreat and immobilize waste from the Hanford tanks. Privatization will be conducted in two phases. The first phase will use two pilot-scale facilities to treat 6 to 13% of the tank waste. In the second phase, a final contract will be awarded, and a full-scale production facility will be constructed to treat the remainder of the waste. Retrieval will be privatized during the second phase of tank waste remediation (DOE-RL 1996a).

The retrieved liquid waste from the tanks will be pretreated to separate the waste into high- and low-activity fractions. Pretreatment will remove such radionuclides as cesium, strontium, and technetium from the retrieved waste. The radionuclides removed during pretreatment will be added to the high-activity fraction of the waste. DOE has petitioned the U.S. Nuclear Regulatory Commission to reclassify the pretreated Hanford tank waste as low activity (of not greater than Class C limits) after separating radionuclides to specified levels. The U.S. Nuclear Regulatory Commission has agreed to a low-activity waste classification (58 FR 12344) provided low-activity



* This represents the Hanford backup strategy. Hanford's baseline is privatization, for which the technical details have not been defined.

Figure A.2. Strategy for Remediation of Tank Waste at DOE Sites waste acceptance specifications and tests are developed that prove long-term waste performance. Highly radioactive sludges will undergo caustic sludge washing to minimize glass volume by reducing the concentration of aluminum, chromium, and zirconium in the sludge. The presence of these components on the sludge requires additional glass formers be added to make a high-quality glass. The dissolved material will be added to the low-activity fraction of the waste.

The low-activity waste from the tanks will be immobilized into a durable solid waste form, placed in large canisters, and disposed of in near-surface vaults on the Hanford Site. HLW will be vitrified, put into stainless steel canisters, and shipped in casks to a geologic repository (DOE 1996).

A.1.1.5 Hanford Site System Closure

The low-activity waste glass produced at Hanford will be retrievably stored on the Hanford Site in subsurface vaults for several decades. If the low-activity waste disposal system is acceptable, the low-activity waste disposal site will be closed in place (DOE-RL 1995).

Under the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994), the tanks will be closed under the State Dangerous Waste Regulations (WAC 173-303). The tank includes the tank structure, the residual waste, and the soils contaminated by tank leaks. In 1994 (Wagoner 1994), the responsibility for cleanup of the soils and piping in the tank farm operable units was transferred to the Office of Waste Management. Before closure of the tanks, the U.S. Nuclear Regulatory Commission must agree that the waste remaining in the tanks is non-HLW. The U.S. Environmental Protection Agency is still developing the rules for LLW (40 CFR 193)[(a)] and residual radioactivity for unrestricted release.

Because of regulatory and technical uncertainties, the tank farm 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.
- Single-tanks and double-shell tanks will be gravel filled.
- Surface barriers will be placed over the single-shell tanks, double-shell tanks, and the LLW vaults.
- The tank farms will be subject to Resource Conservation and Recovery Act closure standards for landfills.

A tank closure plan will be submitted to the Washington State Department of Ecology by December 2004, although a draft plan is available (DOE-RL 1995). The tank closure plan and the National

(a) Proposed "Environmental Protection Standards for Low-Level Radioactive Waste."

Environmental Policy Act review will determine the closure option and methods of long-term monitoring that will be required for the tank farms after 2032.

A.1.1.6 Hanford Site Costs and Schedule

The life-cycle system cost for TWRS is estimated to be over $37 billion in constant 1996 dollars. However, the privatization contractor will largely drive these costs. The privatization contractor will be paid an agreed-upon fee per unit of waste produced that meets DOE specifications. This cost information will not be available until the final privatization contract award in 2005. Estimated costs for major projects and associated completion dates are shown in Tables A.2 and A.3.

Table A.2. Hanford Site System Costs[a]

Needs Breakdown Structure	Waste Management Activity	Estimated Cost ($M)[a]
Manage Tank Waste	Tank farm operations[a]	8,860
	Tank waste characterization[b]	5,400
Process Waste	HLW treatment[c]	15,458
	HLW storage and handling[c]	3,830
System Closure	HLW disposal[c]	3,274
Total		36,822

(a) Constant 1996 dollars (DOE and Ecology 1996a).
(b) Supplementary costs obtained from onsite activity data sheet information.
(c) DOE 1996, pp. WA36, WA50.

Table A.3. Hanford Site Major Milestones[a]

Milestone Title	Completion Date
Mitigate/resolve tank safety issues	2001
Complete tank waste characterization	1999
Complete single-shell tank interim stabilization	2000
Complete tank farm upgrades	2010
Complete closure of single-shell tank farms	2024
• Retrieve waste from all single-shell tanks	2018
Privatize operation of Tank Waste Remediation System pretreatment and immobilization facilities	
• Complete phase I pilot-scale testing	2004
• Award contract for phase II completion	2005
Complete vitrification of Hanford Site tank waste	2028
Complete closure of all double-shell tanks	2032

(a) Source: DOE 1996.

A.1.2 Idaho National Engineering Laboratory

In 1949, the Atomic Energy Commission established the National Reactor Testing Station at INEL, and 52 test reactors were constructed and tested. In the mid-1950s, the Site began receiving and storing wastes from other sites. Most of the reactors were phased out after testing, and only the Advanced Test Reactor is currently operating. One of the major facilities at the Site, the Idaho Chemical Processing Plant, was used to reprocess spent nuclear fuel from reactor operations. 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 of many facilities is underway, resulting in ongoing production of liquid waste.

INEL consists of eight major facility areas: Test Area North, Test Reactor Area, Idaho Chemical Processing Plant, 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 Idaho Chemical Processing Plant (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. Localized flooding of these streams can occur when frozen and melting snow combines with heavy spring rains.
- INEL overlies the Snake River Aquifer, which is the largest aquifer in Idaho. Depth to the aquifer from the Site varies from 61 m (200 ft) in the north to over 274 m (900 ft) in the south.
- 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.).
- The population within 80 km (50 mi) is 250,000 (DOE-ID 1995b, App. B).

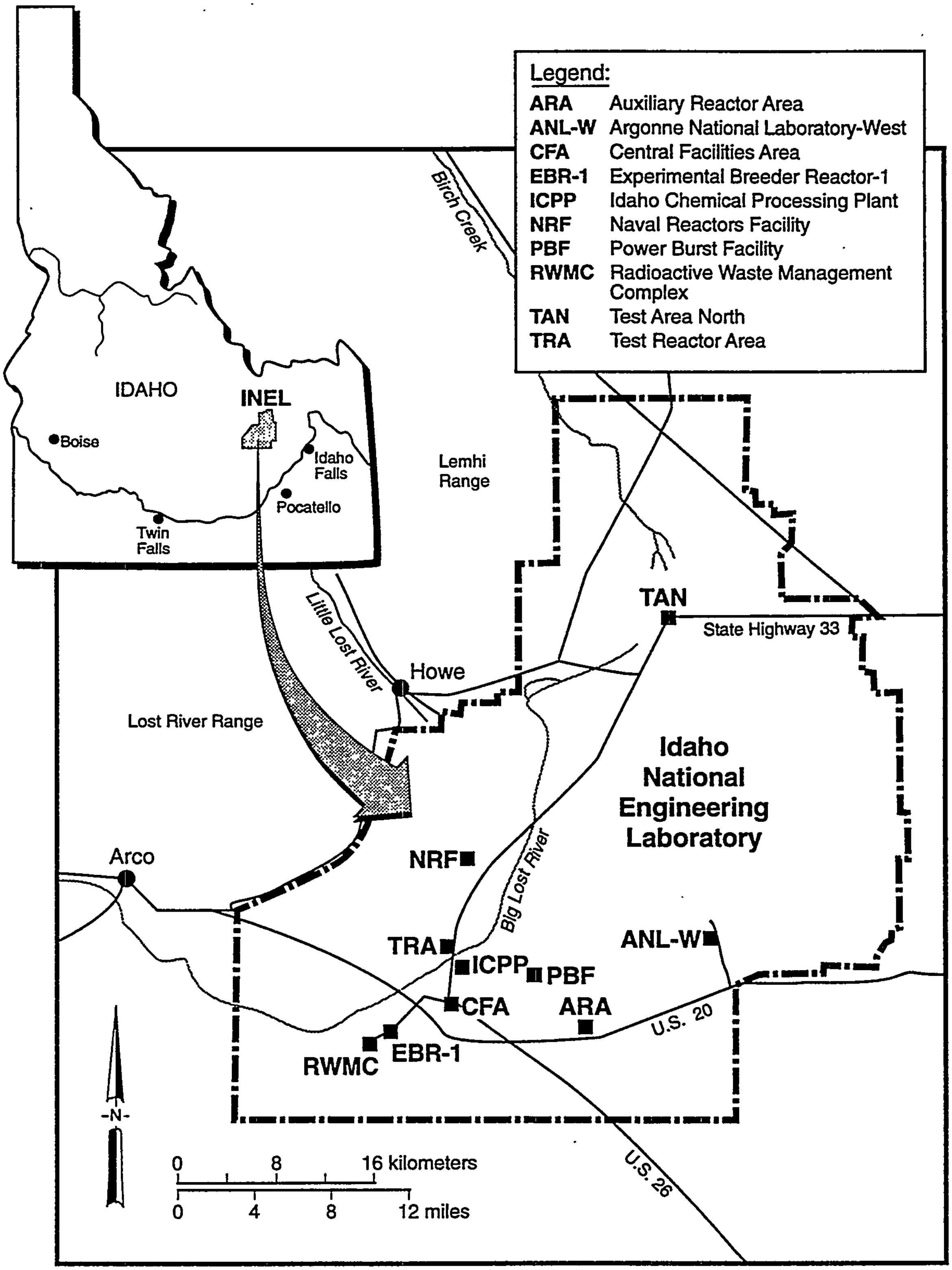


Figure A.3. Idaho National Engineering Laboratory and Major Facilities

A.1.2.1 INEL Tanks and Calcine Bins

HLW at INEL is stored in stainless steel tanks (acidic liquids) and stainless steel calcine bins (solids). 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 contained in underground concrete vaults. 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 five pillar and panel tanks must be removed from service by March 31, 2009. All remaining tanks must be removed from service by 2012.

From 1963 until shutdown in 1981, liquid HLW was evaporated and oxidized in a high temperature fluidized bed in the waste calcining facility. The calcined solids were then pneumatically transferred through underground pipelines to binsets in the Calcine Solids Storage Facility. Newly generated waste is calcined in the New Waste Calciner Facility: waste from the tanks is also being calcined to free tank space and allow tanks to be removed from service. Operating the New Waste Calciner Facility produces 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 2012 without some major improvement in the flowsheet or constructing 3,785 m^3 (1 million gal) of new process surge tanks to support continued operations.

There are seven calcine solids storage facilities, including one newly constructed facility. HLW calcine from these facilities must be retrieved and vitrified. Calcine is stored in stainless steel binsets 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 approximately 7.2 million L (1.9 million gal) of liquid HLW containing 2 MCi in 11 stainless steel tanks. The radioactive contents of the waste is summarized in Table A.1. Of this liquid HLW, about 1.3 million L (300,000 gal) is HLW. The rest of the waste is sodium-bearing liquid waste. Site activities over the next 5 years will generate about 2.4 million L (640,000 gal) of liquid HLW and 2 million L (540,000 gal) of calcined solids (DOE-ID 1995a).

The square vault tank (WM-189) contains liquid HLW, while the other 10 tanks contain sodium-bearing liquid waste. No HLW from reprocessing activities has been added to the tanks since 1992. However, about 20,000 L (5,000 gal) of sodium-bearing waste is being added to the tanks per month from facility decontamination and decommissioning, offgas system operation, and spent nuclear fuel storage. Most newly generated liquid wastes are initially treated by the Process Equipment Waste Evaporator. The concentrated liquid wastes are then sent to the tanks.

Construction of the new high-level liquid waste evaporator facility is underway, and the facility is scheduled to come on-line in 1996. The evaporator will process selected waste stored in the tank farms to reduce the volume and improve its treatability.

Approximately 3.8 million L (1 million gal) of calcined solid waste containing about 49.6 MCi is stored in vaults (DOE 1995b).

A.1.2.3 INEL Regulatory Drivers

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

- Settlement Agreement between the Governor of Idaho, DOE, and the Department of the Navy (Public Service Co. of Colorado v. Batt). This agreement accelerates the schedules at INEL as follows:

  - Commence operation of the HLW evaporator by October 31, 1996, and operate the evaporator enough to reduce the tank farm liquid waste volume by no fewer than 1,250,000 L (330,000 gal) by December 31, 1997.

  - Complete the process of calcining all remaining nonsodium-bearing liquid currently at INEL by June 30, 1998.

  - Start calcination of sodium-bearing liquid waste by June 1, 2001, and complete calcination of sodium-bearing liquid waste by December 31, 2012.

  - Issue a record of decision to begin treatment of calcined waste by December 31, 2009, and complete treatment of all calcined waste by December 31, 2035.

- Final Site Treatment Plan (DOE-ID 1995a). This plan defines the schedule of commitments for processing radioactive liquid and calcine wastes for disposal. The plan is consistent with the new settlement agreement.

- INEL Site-wide EIS record of decision, June 1995. A record of decision was issued to treat sodium-bearing liquid waste using radionuclide separation processes in the Idaho Chemical Processing Plant tank farm and to vitrify the calcine from New Waste Calciner Facility. An additional EIS will be completed in 1999 that selects the final remediation strategy for HLW.

- Idaho Federal Facility Agreement and Consent Order, December 1991. This is an agreement between the U.S. Environmental Protection Agency, the DOE, and the Idaho Department of Health and Welfare. This agreement establishes procedures for addressing releases of hazardous substances.

- Notice of Noncompliance Consent Order, April 1992. This order states that 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.

- Modified Notice of Noncompliance Consent Order, March 1994. This order issued by the U.S. Environmental Protection Agency 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 Resource

Conservation and Recovery Act-contained storage. The Modified Notice of Noncompliance 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. All tanks must be taken out service by June 30, 2105.

A.1.2.4 INEL Remediation System Description

The Idaho Chemical Processing Plant Proposed Waste Management Strategy is illustrated in Figure A.2. At INEL, all waste streams managed under Environmental Management will be integrated, treated, and prepared for shipment. This means that the Remote Handled Immobilization Facility will treat TRU and HLW. Waste treatment activities are briefly described as follows:

- The New Waste Calciner Facility will continue to operate until approximately 2012. During this time, it will treat sufficient waste to meet the consent order requirements.

- New tanks will be brought on-line by 2012, if necessary, to provide the necessary surge capacity for continued Idaho Chemical Processing Plant operations after the last of the old tanks are taken out of service.

- The Remote Handled Immobilization Facility will be brought on-line in 2017, and remote-handled TRU will be processed from 2017 to 2019.

- After 2019, separation and vitrification of the HLW, stored calcine, and any residual or future liquid wastes will occur in the Remote Handled Immoblization Facility and continue until 2035.

- Radioactive liquids stored in the tank farms and dissolved calcine will be processed via TRU extraction, strontium extraction, and ion exchange at the Remote Handled Immobilization Facility, and the concentrated HLW will be sent to the vitrification plant. Mercury will be removed from the HLW feed stream before vitrification.

- Liquid LLW will be collected from the ion-exchange column, concentrated in the LLW denitrator, and treated to remove mercury. The concentrated slurry from the LLW denitrator will be mixed with grout, poured into steel drums, and transferred to the LLW Interim Storage Facility (DOE-ID 1994).

"An alternative HLW process plan is being considered to reduce costs. Waste would be collected and stored in the tanks rather than be calcined after 2001. The RHIF would operate in two phases beginning in 2010. Phase I would consist of operating a separations/grouting facility to empty the tank farms by 2012. Phases II would consist of calcine dissolution and vitrification beginning in 2015. Twenty years (rather than 15) would be required for calcine treatment." (See letter to T. L. Wichmann from W. B. Palmer dated April 25, 1996.) The RHIF mentioned in the quote is the Remote Handled Immobilization Facility.

A.1.2.5 INEL System Closure

The INEL closure strategy has not been finalized. It must address the HLW tank farm residuals and final disposal of the LLW grout. The HLW will be vitrified and sent to a Federal geologic repository.

About 8 cm (3 in.) of a liquid heel that may contain sludge will remain on the bottom of the tanks after retrieval. The removal of this sludge is part of the Resource Conservation and Recovery Act closure activities that start in about 2009.[a] After removal of the heels, INEL tanks will be closed as Resource Conservation and Recovery Act treatment, storage, and/or disposal units. A strategy is currently being evaluated that stabilizes some tanks containing sodium-bearing liquid waste by grouting them in-place.

After mixing the LLW with a cement-based mixture, the LLW grout will be placed in waste drums and stored. At closure, the drums will be transferred to a landfill for final onsite disposal as Class A LLW.

A.1.2.6 INEL Costs and Schedule

The total system cost for remediation of HLW at INEL is estimated to be about $33 billion in constant 1996 dollars. The distribution of costs and the associated schedule are shown in Tables A.4 and A.5.

Table A.4. Idaho National Engineering Laboratory System Costs[a,b]

Needs Breakdown Structure	Waste Management Activity	Estimated Cost ($M)[c]
Process Waste	HLW treatment	3,030
	HLW storage and handling	101
System Closure	HLW disposal	235
	LLW disposal	20
Total		3,386

(a) Source: DOE 1996 (p. ID51). Breakdown of costs developed from telephone conversation with Advisory Scientist, Lockheed Idaho Technology Company on 7/12/96.
(b) Includes costs for treating the low-activity portion of the waste.
(c) Constant 1996 dollars.

(a) 1995 presentation. Tanks Focus Area High-Level Waste Tank Review Group.

Table A.5. Idaho National Engineering Laboratory Major Milestones[a]

Milestone Title	Completion Date
Restart New Waste Calciner Facility operation	1997
Startup New Waste Calciner Facility for processing sodium-bearing radioactive liquid waste	2001
Cease operation of the New Waste Calciner Facility	2012
Cease use of pillar and panel tanks	2009
Cease use of all tanks without secondary containment	2012
Begin operation of treatment facilities for high-level waste calcine	2019
Complete treatment of all high-level waste so that it can be shipped offsite	2035
(a) Source: Gurley, R., Director High-Level Waste Management, Lockheed Idaho Technologies Company, February 8, 1996. "TFA Request for High Priority TD Schedules and Dates-RNG-22-96." Letter to R. Quinn, Technical Manager Tanks Focus Area, Pacific Northwest National Laboratory.	

A.1.3 Oak Ridge Reservation Overview

Weapons research facilities were established at the Oak Ridge Reservation in 1943. The Oak Ridge Reservation was the pilot plant site for the reactors and separators processes that were later deployed at Hanford and SRS during the Manhattan Project. The Site's role as a developer of uranium enrichment processes for production of nuclear weapons has decreased, but the production of nuclear isotopes for research purposes continues. The Site consists of three major facility areas: the Y-12 Plant, Oak Ridge National Laboratory, and the K-25 Site (see Figure A.4). Waste tanks covered under the Tanks Focus Area are located at Oak Ridge National Laboratory in the Melton Valley and Bethel Valley areas.

The Oak Ridge Reservation is briefly described as follows.

- Oak Ridge Reservation is located on 140 km^2 (54 mi^2) within the corporate city limits of Oak Ridge, Tennessee.

- Facilities occupy about 701 ha (about 1,754 acre) or about 20% of the Oak Ridge Reservation. The remaining 2,806 ha (7,017 acre), or 80% of the 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.) (Turner 1993; DOE-ID 1995b, App. F).

- The population within 80-km (50-mi) radius is 510,000.

A.1.3.1 Oak Ridge Reservation Tanks

There are two types of tanks at Oak Ridge: legacy tanks and active tanks. These tanks are buried underground and vary in design and age. The 63 inactive tanks store legacy wastes. Legacy tanks containing dilute LLW supernatants and associated sludges include the gunite and associated tanks, the old hydrofracture tanks, and other tanks. The gunite and associated tanks consist of 12 (primarily 450,000-L [170,000-gal]) concrete tanks and six 7,500- to 15,000-L (2,000- to 4,000-gal) stainless steel tanks in the Bethel Valley Area. Twelve of the gunite and associated tanks have been identified as either leakers or tanks that receive in-leakage of surface water or groundwater. The Site is actively involved in remediation of the gunite and associated tanks. The current plan is to complete the remedial action by 2010. The old hydrofracture tanks consist of five 50,000- to 95,000-L (13,000- to 25,000-gal) carbon steel tanks. The hydrofracture tanks are located in the Melton Valley Area.

Active tanks store waste from an extensive underground collection, transfer, and storage system that interconnects generator buildings, tanks, and processing facilities. The wastes from the active underground collection system are sent to 13 active 190,000-L (50,000-gal) stainless steel central treatment/storage tanks. Five tanks are evaporator service tanks, and eight are Melton Valley Storage Tanks located approximately 1.6 km (1 mi) from the evaporator area. Liquid LLW concentrate has been stored in the Melton Valley Storage Tanks since 1984, and storage space is now very limited (Turner 1993).

A.1.3.2 Oak Ridge Reservation Wastes

There are about 1.86 million L (490,000 gal) of legacy wastes in Oak Ridge tanks. The waste contains 130,000 Ci (primarily cesium-137, strontium-90, and other fission products) of which 150,000 L (40,000 gal) is TRU sludge and 1.71 million L (450,000 gal) is LLW supernate.

The Melton Valley Storage Tanks have accumulated approximately 1.71 million L (450,000 gal) of waste containing approximately 34,000 Ci (primarily cesium-137, strontium-90, and other fission products). Approximately 946,000 L (250,000 gal) is liquid LLW and 640,000 L (170,000 gal) is TRU sludge. These wastes also contain high concentrations of sodium nitrate.

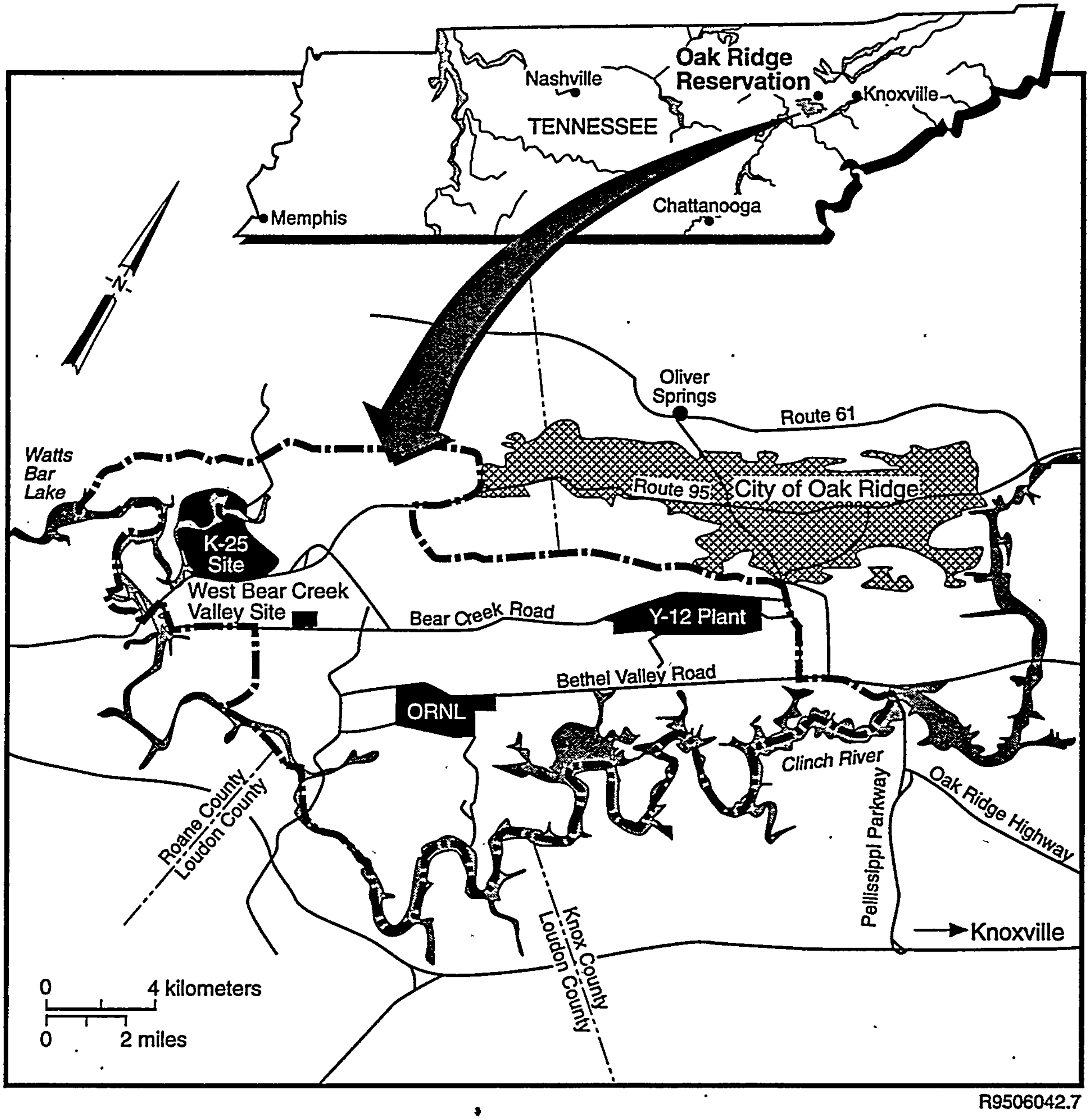


Figure A.4. Oak Ridge Reservation and Major Facilities

Tank waste is continually being generated by ongoing research and development at the Oak Ridge Reservation. There is approximately 1.5 million L/year (400,000 gal/year) of waste being generated, which is reduced through evaporation to approximately 75,000 L (20,000 gal) of waste concentrate.

A.1.3.3 Oak Ridge Reservation Regulatory Drivers

The regulatory drivers for remediating tank wastes are as follows:

- ORNL Federal Facility Agreement (DOE-ORO et al. 1992). This is an interagency agreement between the U.S. Environmental Protection Agency, the DOE, and the Tennessee Department of Environment and Conservation, which was implemented on January 1, 1992. This agreement establishes requirements under CERCLA for the management of tanks. Per this agreement, DOE must remove all tanks from service that operate without secondary containment. Tanks with secondary containment may continue to operate (Turner 1993).

- ORNL waste management plan (Turner 1993). Waste management requirements under Resource Conservation and Recovery Act for active tank wastes are detailed in this plan. The goals for management of liquid LLW are to reduce the volume and to dispose of the waste in facilities that allow for increased environmental protection.

A.1.3.4 Oak Ridge Reservation Remediation System Description

Inactive tanks at Oak Ridge are managed by the Oak Ridge National Laboratory Remedial Action Program. The 18 tanks considered to pose the greatest risk are the gunite and associated tanks. CERCLA treatability studies are planned for tank heel characterization of these tanks using the Light-Duty Utility Arm. CERCLA treatability studies will demonstrate sluicing technologies for waste removal, including conventional sluicing with a nozzle, the Light-Duty Utility Arm, and mixer pumps. The remaining 38 inactive tanks have been tentatively scheduled for remediation based on Site investigation results (Baxter et al. 1995). Lessons learned from the gunite and associated tanks studies will be used to develop remediation strategies for these tanks.

For the active tanks, the plan is to remove and treat the supernates and then treat the sludges. The major contaminants of concern in the Melton Valley Storage Tanks supernates are strontium-90, cesium-137, technetium-99 and ruthenium-106. Nitrates must also be destroyed or removed before the treated waste can be discharged into the environment (ORNL 1994). The waste management strategy for the Melton Valley Storage Tanks is illustrated in Figure A.2. The highlights of the plan are as follows:

- Evaporate the liquid, remove the cesium, and solidify the Melton Valley Storage Tank supernatant 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 the Waste Isolation Pilot Plant.

- Develop separations and immobilization technologies 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:

- Dispose of Melton Valley Storage Tank supernate (greater than Class C) on the Site after removal of the cesium, strontium, technetium, and/or nitrates.

- Enhance stabilization of Melton Valley Storage Tank sludges.

- Develop the capability to vitrify sludge in wiped film evaporator or microwave melter.

- Dispose of sludge on-site after pretreatment.

A.1.3.5 Oak Ridge Reservation System Closure

As stated in the Oak Ridge National Laboratory Federal Facility Agreement, DOE must remove or decontaminate all residues, structures, soils, and equipment associated with tank systems that have been removed from service. The tanks will be closed according to CERCLA requirements for tanks. CERCLA requires a risk-based, prescriptive strategy for establishing clean-up requirements.

A project management plan is in place for remediating three inactive liquid LLW systems tanks, 3001-B, 3004-B, and T-30. Two of the tank structures are being removed, and the remaining concrete vaults will be filled with grout. The other tank will be filled with grout (ORNL 1995).

It has not been decided if treated wastes will be disposed onsite or shipped offsite for final disposal.

A.1.3.6 Oak Ridge Reservation Costs and Schedule

The total system cost for remediation of tank waste at Oak Ridge is estimated to be about $1.1 billion in constant 1996 dollars (assumes 3% inflation). Available information on costs and schedule is provided in Tables A.6 and A.7. Disposal options for tank wastes are now being investigated; thus, they are not included in the costs.

Table A.6. Oak Ridge Reservation System Costs[a]

Needs Breakdown Structure	Waste Management Activity	Estimated Cost ($M)[b]
Process Waste	Process waste	980
System Closure	Disposal	50
	Decontamination and decommissioning	70
Total		1,100

(a) Source: Personal communication with ORNL staff on 6/20/95.
(b) Constant 1996 dollars (assumes 3% inflation).

Table A.7. Oak Ridge Reservation Major Milestones[a]

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 Melton Valley Storage Tank upgrade	1998
Complete Bethel Valley Federal Facility Agreement upgrade	1999
Complete gunite and associated tanks remediation	2010
Complete remediation of liquid LLW Tanks	2030
Complete waste management activities	2045
(a) Source: DOE 1995 (p. TN41) and DOE 1996.	

A.1.4 Savannah River Site Overview

When the Site was established in the early 1950s, the primary mission was to produce special nuclear materials to support U.S. defense (tritium and plutonium-239), space (plutonium-238), and medical programs. 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 including Area C5 for mixed waste storage; Area B for industrial waste disposal; Area E for waste storage, preparation, and disposal; Area Z for saltstone grout-preparation, and Area S for defense waste processing. 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^2) in western South Carolina. Land surrounding the Site is predominately rural woodlands used largely for residences, small farms, forest land, and pasture land.

- F- and H-Areas (where tank farms are located) are in an area of shallow groundwater that flows toward the Upper Three Runs and Four-Mile Branch tributaries to the Savannah River.

- Currently, there is little impact to the water quality of the Savannah River and its tributaries from SRS activities, except for a slight increase in tritium concentration.

- Prevailing winds in the area are from the northeast and the west-southwest.

- The average wind speed from 1987 through 1991 was 3.8 m/s (8.5 mi/h). Atmospheric conditions favor dispersion of air pollutants approximately 79% of the time.

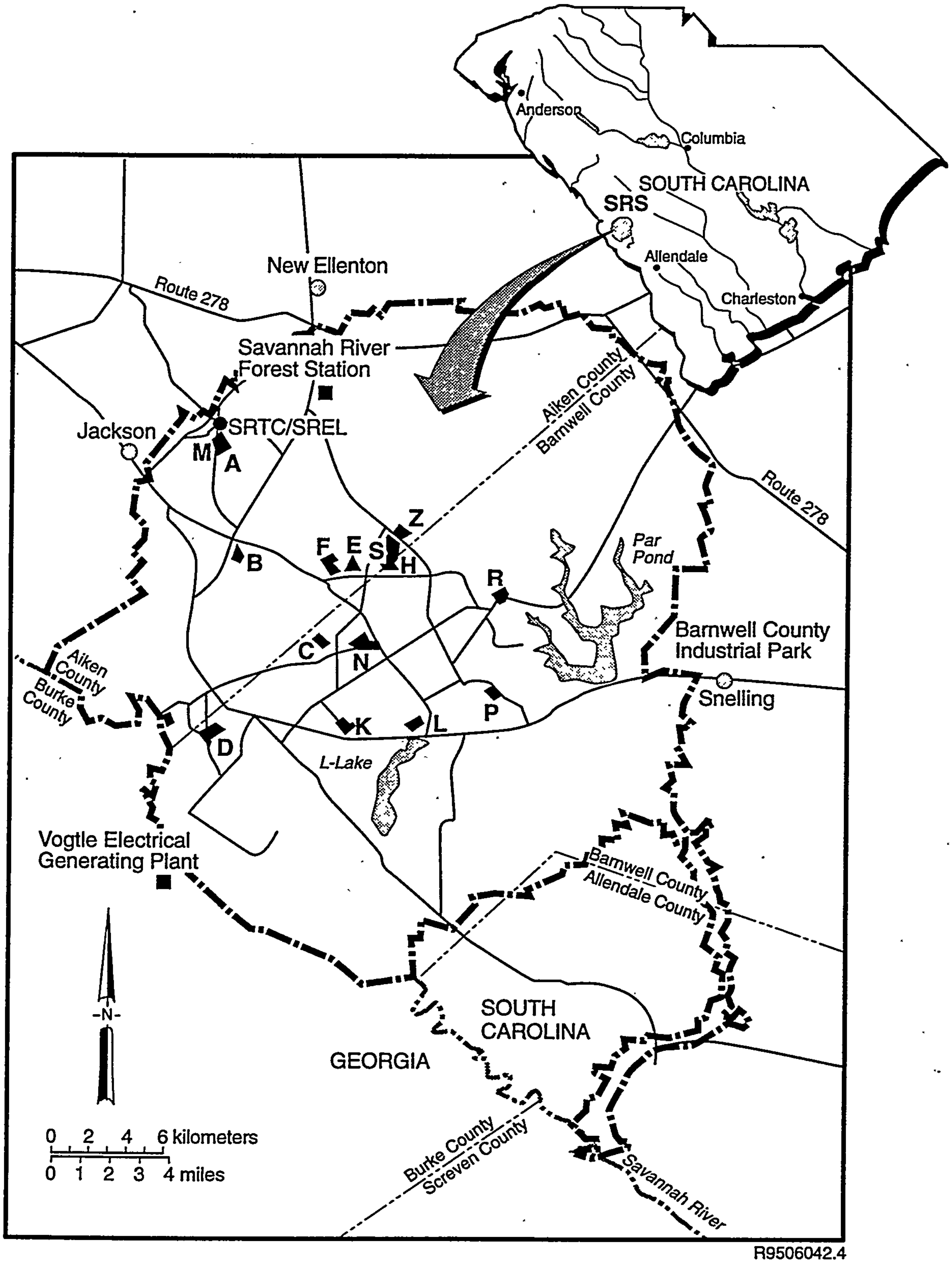


Figure A.5. Savannah River Site and Major Facilities

- Average annual precipitation is 122 cm (48 in.).

- The population within an 80-km (50-mi) radius of the Site is approximately 620,000 (DOE-SRS 1995; DOE-ID 1995b, App. C).

A.1.4.1 SRS Tanks

There are 51 underground storage tanks at SRS, built in four different types (I, II, III, and IV) (see Table A.8). The tanks contain 126.3 million L (33.4 million gal) of liquid HLW. These tanks are located in the F and H Area Tank Farms. Under the Federal Facility Compliance Agreement executed by DOE, the U.S. Environmental Protection Agency, and the South Carolina Department of Health and Environmental Control in 1993, all the Type I, II, and IV tanks (24 tanks) are being retired because they do not have full secondary containment. As shown in Table A.8, nine tanks have had cracks or leaked to the secondary containment and two tanks have had minor water incursions. Four tanks have experienced leaks or spills to the environment, but the leak sites have been cleaned up or stabilized to prevent further spread of contamination.

Table A.8. Status of Savannah River Site Tanks[(a)]

Type	Capacity Liters (gal)	No. of Tanks	Description	Total Curies (%)	Status
I	2,800,000 (740,000)	12	Steel cylinder in concrete with secondary steel pan at partial height and cooling capacity	27	Five failed
II	4,000,000 (1,030,000)	4	Same as Type I tanks	8	All failed
III	4,900,000 (1,300,000)	27	Secondary steel pan at full height and cooling capacity	64	None have failed
IV	4,900,000 1,300,000	8	Uncooled, single wall	<1	Two out of eight failed

(a) Source: DOE SRS 1996, Appendix B.

Type III tanks are still receiving waste from the limited production activities underway at SRS. Two types of waste are being sent to the tank farms: 1) high-heat waste, which contains most of the radio nuclides and must be aged in a high-heat waste tank before evaporation, and 2) low-heat waste. Incoming waste is treated to prevent corrosion of the tank walls. Seven of the 27 Type III tanks are used for purposes other than waste storage; three tanks are used for in-tank precipitation, three are used for extended sludge processing, and one is used as the feed tank for the saltstone manufacturing facility.

The waste management program at SRS is currently installing mixing and transfer pumps on 50 of the HLW tanks to allow retrieval and transfer of waste for processing. Many tanks are being upgraded with air-monitoring equipment to correct deficiencies and bring the tanks into compliance.

A number of miscellaneous tanks are located at SRS. The 568,000-L (150,000-gal) Organic Waste Storage Tank will be used for storing mixed organic waste (mostly benzene) generated at the Defense Waste Processing Facility. Several 95,000-L (25,000-gal) solvent tanks are in the E-Area. The evaporator systems include a mercury collection tank, a cesium removal pump tank and column, and a supernatant collection and diverting tank (2 F only), and a waste concentrate transfer system (DOE-SRS 1995; DOE 1995a). These tanks are not part of the Tanks Focus Area.

A.1.4.2 SRS Wastes

As of December 1994, tank waste consisted of 58.1 million L (15.3 million gal) of liquids containing 231.4 MCi and 68.2 million L (18 million gal) of solids containing 302.3 MCi (DOE 1995b). 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 1995b). Chemical constituents in the supernate are primarily sodium nitrate (49 wt%), sodium nitrite (12 wt%), sodium hydroxide (13 wt%), aluminum tetrahydroxide sodium salt (11 wt%), sodium sulfate (6 wt%), and sodium carbonate (5 wt%). The chemical composition of the sludge consists primarily of aluminum oxide (33 wt%), iron oxide (30 wt%), and sodium salts (6 wt%). Although the waste is classified as high level, about 93% of the volume is low-level salt solution (DOE-SRS 1994). The radionuclide content of the waste is summarized in Table A.1. Most of activity is in the Type III tanks.

SRS 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).

SRS emphasizes volume reduction to manage the newly generated liquid wastes. Volume reduction is performed using evaporation 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 2H Evaporator. Evaporation of the supernate in the tank farms using evaporators results in a third waste form in the tanks, crystallized saltcake.

Approximately 22 million L (5.8 million gal) of HLW will be received in the tank farms as a result of Defense Waste Processing Facility operation. After the facility begins operation, the 2F and 2H Evaporators will not process waste fast enough to keep pace with the facility, so construction of a new evaporator is planned. It is about twice the size of existing evaporators with a 30-year versus a 10-year tube design life. The current startup date for the replacement HLW evaporator is September 2000. (DOE-SRS 1995).

A.1.4.3 SRS Regulatory Drivers

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

- Defense Waste Processing Facility EIS (DOE-SRS 1982) and Supplemental EIS (DOE SRS 1994). The record of decision from the EIS (47 FR 23801) documents the decision to construct and operate the Defense Waste Processing Facility. 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 Defense Waste Processing Facility. The record of decision (60 FR 18589) was issued in April 1995 to complete startup testing and begin operation of the Defense Waste Processing Facility.

- Savannah River Federal Facility Agreement (EPA 1993). This is an agreement between the U.S. Environmental Protection Agency Region IV, the DOE, and the South Carolina Department of Health and 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 (DOE-SRS 1995). This Sitewide EIS provides the basis to select processes to manage wastes generated from ongoing operations and the operation of the Consolidated Incineration Facility. The record of decision from this EIS (60 FR 26845) documents the decision to construct and operate the HLW evaporator and to transfer waste from the storage tanks to the Defense Waste Processing Facility when it becomes operational.

- Site Treatment Plan (WSRC 1995). The Federal Facility Compliance Act requires a site treatment plan for treating and disposing of mixed wastes. The SRS Site Treatment Plan identifies the Defense Waste Processing Facility as the preferred treatment option for treating liquid HLW. The Defense Waste Processing Facility startup occurred in March 1996.

A.1.4.4 SRS Remediation System Description

The SRS remediation strategy is illustrated in Figure A.2. The HLW from the tanks will be treated in the HLW system. The HLW system includes the H Area pretreatment process facilities, H and F Tanks Farms, S Area vitrification, and Z Area saltstone process facilities. There are four processes to pretreat waste before 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/min (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, mixed with caustic to dissolve excess aluminum, and washed. After gravity settling, the salt solution is evaporated and sent to waste storage on in-tank precipitation. The sludge becomes feed to the Defense Waste Processing Facility.

- 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 filtrate produced during the filtering step following in-tank precipitation is stripped of benzene and converted to saltstone grout.

- Washed precipitate from in-tank precipitation is sent to late wash. During late wash, the nitrite added to mitigate corrosion of the storage tank and soluble organic degradation products are removed from the concentrated precipitate. The concentrated precipitate is then sent to the Defense Waste Processing Facility for conversion to glass.

The Defense Waste Processing Facility contains the vitrification processing equipment to vitrify the highly radioactive sludge and precipitate from in-tank precipitation into borosilicate glass. The Defense Waste Processing Facility startup occurred in April 1996. Waste vitrified in the facility is stored in a glass waste storage building for up to 10 years. No permanent disposal for HLW will be provided at the Site. HLW will be shipped offsite for permanent disposal (WSRC 1996).

The saltstone manufacturing plant and disposal vaults will be used to treat and dispose of the low radioactivity salt solution resulting from the in-tank precipitation process. The saltstone plant is constructed and in operation.

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 and 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 1995a). 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 $13 billion in unescalated constant 1996 dollars. The distribution of costs by waste management activity and the associated schedule are provided in Tables A.9 and A.10.

Table A.9. Savannah River Site System Costs[a]

Needs Breakdown Structure	Waste Management Activity	Estimated Cost ($M)[b]
Manage Tank Wastes	F and H Area tank farm operations	3,675
	Tank farm upgrades	19
Process Waste	Replacement high-level waste evaporator	37
	Defense Waste Processing Facility	3,831
	High-level waste removal project	608
	In-tank precipitation	1,505
	Extended sludge processing facility	372
	Saltstone	484
System Closure	High-level waste disposal	2,763
Total		13,294

(a) Source: DOE 1996 (pp. SC30 and SC41).
(b) Constant 1996 dollars.

Table A.10. Savannah River Site Major Milestones[a]

Milestone Title	Completion Date
Begin in-tank precipitation operations	1995
Begin operation of New Waste Transfer Facility	1995
Start operation of Late Wash Facility	1996
Start operation of the Consolidated Incineration Facility	1996
Start operation of Defense Waste Processing Facility	1996
Start operation of new high-level liquid waste evaporator	1998
Remove waste from tanks	2021
Complete Defense Waste Processing Facility activities	2028
Complete saltstone vault high-level waste activities	2028
Complete high-level waste management activities	2028

(a) Source: WSRC 1996 and personal conversation with Neil Davis of SRS on 1/12/96.

A.2 System Risks

The Tanks Focus Area 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 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, several important parameters for analyzing these risks are provided in Table A.11. Five types of parameters are provided:

- technical - This risk arises 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.

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

- 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.

- involved worker - This is cancer risk due to occupational exposure to hazardous chemicals or radiation resulting from tank waste remediation activities to the involved worker. The involved worker is also subject to injury or death from an on-site accident (noncancer).

Table A.11. Summary of Risk Evaluation Parameters for Hanford Site, Idaho Nuclear Engineering Laboratory, Oak Ridge Reservation, and Savannah River Site Tanks[a,b]

	Sites			
Risk Parameters	**Hanford**	**Idaho Nuclear Engineering Laboratory**	**Oak Ridge Reservation**	**Savannah River Site**
Groundwater/Public				
No. of tanks	149 single-shell 28 double-shell	11 tanks 7 calcine solids storage facility	63 inactive tanks 34 active tanks	51
Vol. of tank waste (million L/million gal)	208/55	7.2/1.9 liquid waste 3.8/1 calcined	1.86/0.49 legacy 1.5/0.4 active (per year)	126.3/33.4
Tanks known or assumed to have leaked	67	Not applicable	12	11
Total curies (Mci)	70.1 (liquid) 128.3 (solid)	2 in tanks 49.6 in calcine solids storage facility	0.13 legacy 0.034 active	231.4 (liquid) 302.3 (solid)
Vol. of leaks (L/gal)	3,800,000/1,000,000	Minimal	Minimal	75-113/20-30
Depth to water table (m/ft)	55-95/180-310	61/274/200-900	0.3 to 20.4/1 to 67	40/130
Annual precipitation (cm/in.)	16/6.3	22/8.7	130.9/51.5	122/48
Air/Noninvolved Worker and Public				
Safety concerns	Watch List	Potential for flammable gas generation heel	None	None
Average wind speed (m/s; mi/h)	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	620,000
Onsite population	11,000	8,000	16,000	20,000

Table A.11. (contd)

	Sites			
Risk Parameters	**Hanford**	**Idaho National Engineering Laboratory**	**Oak Ridge Reservation**	**Savannah River Site**
Groundwater/Public				
Involved Worker				
No. of proposed remediation workers (FTE)	1,000	Not available	Not available	Not available
Programmatic				
Cost ($ billion)	36.8	3.4	1.1	13.3
Schedule	2032	2035	2045	2028
Technical				
Status of technology	Unproven	Unproven	Unproven	Unproven
Scale of effort	Large	Medium	Small	Large

(a) Environmental information (DOE-ID 1995b, App. A, B, C, and F; Turner 1993).
(b) Cost and schedule information (DOE 1996) and site representatives.

The risks drivers for these are briefly discussed for each of the Tanks Focus Area sites in the following sections.

A.2.1 Hanford Site Risks

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

A.2.1.1 Hanford Site Technical Risks

Technical risks for the Hanford baseline are increased due to the number of unproven technologies required for the breadth and scale of the remediation (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. There may not be a repository; however, if it is built, some of the waste will be treated before it is available. This necessitates interim storage of the waste.

Technical risk to DOE may be reduced by the privatization strategy being implemented at Hanford. Under the proposed privatization strategy, private companies will accept much of the technical risk associated with treatment of the waste. The methods for processing the wastes will not be restricted to vitrification. However, before employing a technology other than vitrification, the performing contractor must prove that the alternative technology meets or exceeds the performance standards applicable to vitrification. DOE efforts will be focused on defining and monitoring the requirements to be met by the selected contractor for the treated tank waste to be returned to DOE control after treatment. DOE continues to be responsible for safe operation of the tank farm, characterization of the waste, and site closure.

High-priority technology development needs identified by the Site Technology Coordination Group to reduce technical risk for the Hanford baseline include the following:

- Off-riser sampling technology and in situ measurement technology to gather data on waste energetics and moisture in single- and double-shell tanks.
- High pressure sluicing technology and alternative retrieval methods to improve the waste retrieval system performance for tanks.
- Real-time waste property measurement instrumentation to monitor waste transfers for leaks and line breaks, trapped gas, and line plugging.
- Technology for management and control of leakage during tank storage and retrieval operations and after disposal of the immobilized LLW in onsite vaults.

- Technically viable, practical approaches for removal of technetium, TRUs, strontium, and cesium from Hanford tank supernatants. Associated processes for immobilizing the solid wastes produced from these removal operations must also be demonstrated.

- Solid-liquid separation of fine solids and colloidal particles from Hanford supernatants to assure that the LLW stream will have acceptably low concentrations of insoluble radioactive material, principally strontium-90 and TRU radioisotopes.

- Small-scale testing of pretreatment processes, melters, process instrumentation, and offgas treatment systems to support the design of facilities by the private sector to treat Hanford LLW and HLW streams.

- Inspection and testing tools to verify conformance with waste acceptance specifications before DOE takes custody of the LLW and HLW products from the immobilization vendors.

- Criteria for closing tanks at a semiarid site, because this work is necessary to provide a technical basis for performance specifications for waste retrieval systems.

A.2.1.2 Hanford Site Programmatic Risks

This is a time of considerable programmatic risks at Hanford for a number of reasons:

- The DOE Richland Operations Office awarded the management and integration contract for the Hanford Site to Fluor Daniel Hanford, Inc. The contractor will assume contract responsibilities on October 1, 1996. The contract is performance-based and is intended to reduce costs and milestone slippage.

- A *Hanford Federal Facility Agreement and Consent Order* TWRS Privatization Change Package has been submitted, and the agencies involved are seeking public comment. DOE plans for private financing and operation of the tank waste treatment facilities. The change will not affect major milestones (e.g., the consent order states that cleanup of the tanks must be completed by 2029) for the processing of tank waste, except that LLW will be treated by 2024 instead of 2028. The contract is performance-based and is intended to reduce costs and milestone slippage. However, some Site studies indicate that pilot-scale treatment of actual tank waste, which is part of privatization, will not uncover operational problems and will actually increase cost and schedule risk (Gasper 1995).

- Defense Nuclear Facilities Safety Board Recommendation 93-5 (DOE-RL 1994) will not be met. This recommendation required safety-related sampling and analysis to be completed on specified tanks by July 1995 and on other tanks by July 1996. The failure may result in downsizing the sampling campaigns at Hanford or delaying construction of TWRS facilities until characterization is complete.

A.2.1.3 Hanford Site Health and Safety Risks

The risks from tank waste remediation alternatives have been evaluated in the TWRS EIS (DOE and Ecology 1996a). The relative distribution of environmental, safety, and health risks for the various tank waste remediation alternatives are shown in Table A.12. As shown, the no action alternative is not acceptable due to the danger of tank farm accidents and contaminants eventually leaking from the tanks and leaching to the groundwater. If an ex situ remediation alternative is selected, the most significant short-term environmental, safety, and health risks are from accidents as employees commute to work or transport waste to the repository. In situ disposal of waste minimizes worker and transportation risks, but in situ disposal results in high risk to the intruder over the short term and may have significant accident risk if in situ vitrification is deployed. Ex situ treatment of tank waste is currently favored, because long-term risk to the public from migration of contaminants to the groundwater is the least for ex situ remediation alternatives.

Table A.12. Risk Associated with Remediation of Hanford Site Waste Tanks[a]

	Source of Risk					
	Traffic Fatalities [b]		Increased Cancer Fatalities			
Alternative	**Commute**	**Repository**	**Worker** [c]	**Worker**	**Public**	**Public**
No action	25	0.00	<1 (3)	20[d]	2[d]	GW
In situ fill and cap	6	0.00	<1 (1)	20[d]	2[d]	I
In situ vitrification	13	0.00	<1 (2)	46[e]	5[e]	I
Ex situ intermediate separations	21	3 (13)	3 (2)	20[d]	2[d]	Low
Ex situ no separations	10	2 (19)	4 (2)	20[d]	2[d]	Low
Ex situ extensive separations	20	3 (8)	3 (2)	20[d]	2[d]	Low

(a) Source: DOE and Ecology 1996a.
(b) Employees commuting to and from work and transporting waste to the high-level waste repository. Values in parenthesis are the additional deaths from cancer due to radiological exposure to the public from the unlikely event of a serious transportation accident on the trip to the repository.
(c) Increased number of fatal cancers in exposed worker population. Values in parenthesis are the deaths due to occupational accidents during construction and operation.
(d) Hydrogen burn in waste storage tank.
(e) Offgas duct rupture.
GW= The risk to the groundwater user is unacceptable.
I = The risk to the intruder is fatal.

A.2.2 Idaho National Engineering Laboratory Risks

A regulatory agreement is now in place that drives the remediation strategy at INEL. The recent settlement agreement between the Governor of Idaho and the DOE Idaho Operations Office requires that all waste be transported out of Idaho by 2035. It also accelerates treatment of calcined waste so that it can be more quickly put into a form for transport out of Idaho to a permanent geologic repository. Requirements to accelerate the schedule and reduce schedule risks for the INEL baseline are discussed in the following sections.

A.2.2.1 INEL Technical Risks

Because of the settlement agreement, INEL has proposed a strategy to remove, process, and immobilize liquid HLW in the tank by calcining it. Modeling and simulation efforts have shown that without an improved calcination flowsheet for treating existing tank waste, achieving a cease use of the tank farms by 2012 will not occur. An alternative calcination flowsheet is viewed at this time as the only reasonable strategy to comply with the settlement agreement. Development of this flowsheet is identified as critical to meeting regulatory drivers.

Other high-priority technology development activities identified by INEL to address technical risks for the Site's remediation strategy include the following.

- End effectors and Light-Duty Utility Arm deployment systems are needed to support in situ tank waste characterization, nondestructive examination of tank walls, and heel retrieval for the FY97 Idaho Chemical Processing Plant Tank Heel Removal Project.

- Technology is needed for removal of undissolved solids from tank waste and dissolved calcine and for partitioning of radionuclides (TRU, strontium, technetium, and cesium) from acidic liquid feeds (liquid waste and dissolved calcine).

- A grout process must be developed for the immobilization of the low-activity waste fraction of the sodium-bearing tank waste that is acceptable to stakeholders.

- An on-line process monitor is needed for elemental analysis of the calcine product.

- Glass formulations are needed for immobilization of the high-activity waste fraction of the sodium-bearing liquid waste and calcine.

- Final waste acceptance criteria are not yet available for the LLW grout.

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

- Risk-based closure criteria is needed that defines the level to which tanks must be retrieved before closure.

A.2.2.2 INEL Programmatic Risks

INEL is struggling to meet regulatory requirements to cease use of a number of existing tanks. This is especially true since the settlement agreement between the Governor of Idaho and DOE Idaho Operations Office requires that the 11 tanks be taken out of service by 2012, an acceleration of 3 years over the Federal Facility Agreement and Consent Order. 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 the regulatory agreement will not be met.[a]

Based on DOE's future funding projections, the costs for proposed INEL treatment facilities will exceed available funding. This is especially true since schedules for HLW remediation have been accelerated.

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-ID 1995b, App. B). Long-term risk to the public is possible from migration of tank residuals, tank leaks to the groundwater, or any other inadvertent release of HLW to the environment. For these reasons, INEL would like all HLW removed from the Site as quickly as possible.

Some reasons or concern about inadvertent release at INEL include the potential for near-term environmental, safety, and health risks if flammable gas generation occurs in the tank heels. This risk is being investigated by better characterizing the tank heels. There is also a seismic issue within binset 1 due to an overstress on the vault walls. The likelihood of failure during an earthquake is unknown.

A.2.3 Oak Ridge Reservation Risks

The tanks at the Oak Ridge Reservation contain liquid LLW, which reduces exposure risks and makes the Site a desirable location for prototype testing of tank remediation technology. Risks are discussed briefly in the following sections.

A.2.3.1 Oak Ridge Reservation Technical Risks

Technology needs to reduce technical risks at Oak Ridge Reservation involve the following:

- in situ tank and waste characterization methods to support remediation decisions and regulatory drivers

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(a) Gurley, R. Director High-Level Waste Management, Lockheed, Idaho Technology Company. February 8, 1996. "TFA Requests for High Priority TD Schedules and Dates-RNG-22-96." Letter to RK Quinn, Technical Manager Tanks Focus Area, Pacific Northwest National Laboratory, Richland, Washington.

- mechanical mixing and mobilization equipment for bulk sludge retrieval and slurry transport
- end effectors and deployment systems for heel waste retrieval and characterization for gunite and associated tanks CERCLA treatability studies
- waste forms and waste form production processes for immobilizing HLW sludges and secondary wastes
- cesium, strontium, technetium, and TRU separations and immobilization processes for supernate, sludges, newly generated waste, and source treatment
- tank closure criteria and strategies to resolve ambiguous tank closure requirements.

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 Reservation Programmatic Risks

A strategy for remediating inactive tank wastes at Oak Ridge has not been developed to date: this introduces programmatic risk. Lower cost 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 to reduce costs. Commercial treatment is being encouraged, and several proof-of-process awards are being negotiated.

A.2.3.3 Oak Ridge Reservation 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 near the Site are used by the public (DOE-ID 1995b, App. F) makes secondary containment, leak detection, and water balance monitoring very important for preventing human health risk.

A.2.4 Savannah River Site Risks

Tank retrieval has been initiated, and process development is well underway. There are risks that must be addressed associated with startup of vitrification facilities and safe retrieval of waste from the tanks. These risks are discussed in the following sections.

A.2.4.1 SRS Technical Risks

SRS's primary interests are to minimize tank leaks during storage and retrieval, to minimize the generation of secondary wastes, and to enhance baseline technology, including the following:

- improved tank instrumentation to measure tank corrosion and annulus inspection devices

- improved slurry pumps and mixing techniques for removing tank wastes and methods to reduce sludge settling and compaction during retrieval

- methods to remove tank heels, mired equipment, and hard sludges from tanks

- ion-exchange equipment and new resins for cesium removal as an alternative to in-tank precipitation

- improved Defense Waste Processing Facility laboratories and analytical methods for feed and waste form testing and improved product composition control systems

- recycle stream treatment and other methods to minimize secondary waste production

- technology to extend the life of Defense Waste Processing Facility melters.

A.2.4.2 SRS Programmatic Risks

The SRS is seeking proposals from contractor teams to manage defense and environmental activities. The contract is worth approximately $6 billion over 5 years. Westinghouse Savannah River Company, the existing contractor, is the only contractor to submit a proposal. The contract will reduce the size of the team managing the Site and ensure that as much of the work as possible is outsourced under fixed price performance-oriented contracts. The impact of these changes on the ability of the Site to meet baseline budgets and schedules is unknown.

SRS is considering privatization of the LLW saltstone grout facility. It is anticipated that lessons learned from Hanford privatization efforts will impact the level to which privatization is pursued by SRS in the future.

Current funding levels of the HLW system will not be adequate, and this may result in changes to the baseline strategy if budget levels are not increased. This is especially true if the amount of HLW produced at the Site increases, because SRS is selected to dispose of numerous stored nuclear fuel assemblies across the DOE complex. Nearly $1 billion of projected funding has been removed from the HLW program in the last 2 years. In 1995, SRS had proposed extending Site milestones by 40 years to operate with the reduced budget (i.e., complete Defense Waste Processing Facility activities in 2065 instead of 2025). However, this strategy was not acceptable. The current strategy is to meet the original milestones with the proposed baseline and work with Congress to obtain the required budget.

A.2.4.3 SRS Health and Safety Risks

Groundwater contamination is a concern for the public, because the aquifer below the SRS is at an average depth of 9 m to 13 m (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 the Savannah River or 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. Efforts to reduce tank leakage during storage and retrieval are important to minimizing health and safety risk from future groundwater contamination.

A.3 Stakeholder Involvement and Issues

The Tanks Focus Area technology development program seeks to reflect the issues and concerns of stakeholders, including regulators and technology users at each of the sites. The Tanks Focus Area's objective is to work with the stakeholders in the evaluation of tank technologies considered for funding and deployment and to ensure that tests and demonstrations address stakeholders' and regulators' concerns. Environmental Management has established STCGs to facilitate this process. Site-specific advisory boards are the primary DOE forum for site-wide stakeholder involvement. The Community Leaders Network also provides a network with which the Tanks Focus Area involves stakeholders in tanks technology development.

Stakeholder involvement and concerns are similar across the Tanks Focus Area sites. The following sections describe the Tanks Focus Area strategy for stakeholder involvement at each of the sites and a preliminary discussion of the issues being addressed.

A.3.1 Hanford Site

The Hanford STCG has the ability to represent stakeholders' views and concerns. The group has two levels: the management council and four subgroups affiliated with the four national focus areas. The STCG tanks subgroup provides a direct way for the Tanks Focus Area to work with the larger group and stakeholders in evaluating tanks technology.

Regulators, representatives of environmental and public interest groups, representative of the TWRS program, and Native American tribes serve on the Hanford STCG management council. Three stakeholders on the management council are members of the Hanford Advisory Board that addresses major policy issues related to Hanford cleanup. Several members of the Hanford STCG also serve on the Community Leaders Network tanks subcommittee.

According to the Hanford Tank Wastes Task Force (1993), Hanford stakeholders are very concerned with safe storage of tank waste. 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. The renegotiated *Hanford Federal Facility Agreement and Consent Order* reflects public concern over potential radiation exposure to users of the Hanford Reach and the Columbia River. The public repeatedly said that mixing tank waste with grout was unacceptable, and the new *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994) replaces grout with a retrievable glass waste form.

A.3.2 Idaho National Engineering Laboratory

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

INEL stakeholders want waste treatment to progress using the best-available technology. INEL is focusing on technology development for treating high-level calcine wastes, i.e., getting these wastes into a form for near- and mid-term storage (approximately 50 years). 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. Areas of greatest risk should be addressed first. 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.3.3 Oak Ridge Reservation

The Oak Ridge STCG consists of a policy-making group and subgroups affiliated with each focus area including tanks. A principal focus of the STCG's activity has been to develop a comprehensive needs assessment for the Site. The heads of the subgroups and the STCG coordinator are developing methods and criteria for ranking needs across the subgroups.

DOE Oak Ridge Operations has developed an Environmental Management Public Involvement Program. A site-specific advisory board for the Site is being established. A Local Oversight Committee was set up by the state of Tennessee and the Site established a Citizens Advisory Board of about 20 people. This board is a potential point of contact for understanding stakeholder concerns.

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 (DOE-ORO 1995).

A.3.4 Savannah River Site

The primary goal of the STCG at SRS is to facilitate implementation of needed technologies and to save time and money in the process. The STCG has a HLW subgroup with responsibility for defining Site technology needs for tank waste remediation.

The SRS STCG has identified stakeholder issues of concern for HLW tanks. Many of these 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.4 Tanks Focus Area Site Summary and Issues

Outstanding considerations regarding the Tanks Focus Area's link to site needs are discussed in the following sections. This includes the Tanks Focus Area technology that is currently addressing site needs and identification of site needs that may be important in the future.

A.4.1 Hanford Site

Tanks Focus Area 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
- leaks detection capability for single-shell 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
- enhanced sludge washing and alternatives to enhanced sludge washing
- alkaline strontium/technetium/TRU removal to allow more extensive separations of HLW from LLW to reduce HLW volume
- minor component solubility and higher wash loading for HLW
- advanced melter materials and advanced immobilization processes.

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 Tanks Focus Area supplements Hanford tank technology efforts by funding alternative waste removal and separation processes. However, there is little emphasis in the Tanks Focus Area on in situ or other alternative treatments of tank wastes due to funding limitations.

A.4.2 Idaho National Engineering Laboratory

The Tanks Focus Area 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) INEL's baseline is changing rapidly; therefore, the Tanks Focus Area response may need to be reassessed.

- A demonstration at the Oak Ridge Reservation will produce LLW forms for subsequent testing. The results of the demonstration will help INEL to make decisions regarding waste formulations and disposal options.

- Tank leak detection and monitoring technology will help minimize tank leaks and avoid future groundwater contamination of the Snake River Aquifer. Tanks Focus Area-funded technology to remove tank heels will protect the Snake River Aquifer by minimizing the amount of waste left in place.

The Tanks Focus Area is not funding technology to assist in retrieving calcined waste, decontaminating the HLW calcine vaults, or separating 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.4.3 Oak Ridge Reservation

The Tanks Focus Area addresses many of the technical risks at the Oak Ridge Reservation. 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 fiscal years 1996-1997 using a full-scale modular cesium ion-exchange processing unit. A full-scale subatmospheric mobile evaporator underwent out-of-tank hot testing in fiscal years 1995-1996. The Light-Duty Utility Arm will be tested in gunite tank treatability studies in fiscal year 1997, including retrieval and deployment of sampling end effectors. A demonstration of grout versus glass for immobilization of retrieved gunite and associated tank waste in fiscal year 1997 and fiscal year 1998 will assist the Site in selecting full-scale technology for waste immoblization.

Oak Ridge may be able to ship a substantial portion of the waste offsite for treatment. If this option proves viable, the need for technology development to treat waste at Oak Ridge may need to be examined. The ability to transfer technologies demonstrated at the Oak Ridge Reservation to other sites is of particular concern. Efforts must be made to ensure that available Melton Valley Storage Tank waste streams are supplemented with hot waste samples from other sites if the constituents of concern at those sites are not represented in the Melton Valley Storage Tank waste.

A.4.4 Savannah River Site

The Tanks Focus Area is addressing a number of the technical projects to enhance the baseline at SRS, including in situ waste characterization, small-scale melter studies, improved hydraulic waste removal techniques, technology to vitrify 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. Effective technologies for decontamination, decommissioning, and closure are a high priority at the Site, and Tanks Focus Area development efforts in this area will likely benefit all DOE sites.

A.5 Next Steps

The Tanks Focus Area is examining relative risks and costs across the complex to ensure that its program addresses needs with the greatest risk and its solutions offer significant risk and cost reductions worthy of its investments. The site-specific risk data sheets currently being validated are a source of future data. The Tanks Focus Area 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 decisions.

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 Tanks Focus Area will actively support site activities directed at involving stakeholders in technology demonstrations and deployment decisions.

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Appendix B - Problem Element Descriptions

The Tanks Focus Area (TFA) Technical Team constructed problem elements that describe areas of concern in high-level tank waste remediation. Into this structure were placed high-impact needs at the four tank sites: Hanford, Idaho National Engineering Laboratory (INEL), Oak Ridge Reservation (ORR), and Savannah River Site (SRS). These needs were determined from the needs assessment process, which is described in Section 3 of this document. These problem 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 problem elements define a path forward to solve the fundamental remediation problems underlying specific site requests.

The problem elements were defined initially by the TFA Technical Team using the information from the needs assessment (TFA 1996) and in response to discussions with site users. Explicit criteria guiding problem 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 problem 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 problem 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 FY97 work plan will include more specific scope, schedule, and budget information on the problem elements.

B.1 Problem Elements

The TFA problem elements are described on the following pages; together, these problem elements form the core of the FY97-99 TFA program. Each element includes the following sections: Title, Problem Element Description, Priority Site Needs, Problem Statement, Path to Solution, FY97-99 Scope, Schedule, and Requested Budget. Table B.1 lists the problem elements; they are organized by breakdown structure number.

Table B.1. Problem Element List

Problem Element Title: 1.1.1.1 Monitor Tank Integrity

Problem Element Description

Tank integrity is a critical issue during both long-term storage of radioactive tank wastes and during retrieval of tank wastes. This problem element addresses methods to monitor the integrity of tanks to aid in early detection of tank problems that may lead to leakage.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual waste from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also indirectly benefit a related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	169	INEL	Develop "Fly By" NDE Inspection System
Secondary	382	SRS	Develop Real-Time Corrosion Monitoring Techniques
	586	Hanford	NDE of Single-Shell Tanks

Problem Statement

INEL, SRS, and Hanford have identified high-priority needs to monitor and/or inspect for tank integrity and corrosion.

INEL

There is a need to perform nondestructive examination of tank walls to determine structural integrity. Current methods are limited to contact examinations and usually require a cleaned surface and coupling between the head and structure being inspected. This is very difficult in underground storage tanks and improved methods that allow inspection to be performed without direct contact or through liquids are needed. The knuckle region of tanks where the side walls and bottoms were joined by welding are believed to be primary sites for degradation and leakage to occur. This inspection must be performed remotely and provide quantitative data on tank structure needed to ensure safety of current tank configurations and evaluate side loading limits. This type of data will be required in planning future tank remediation.

SRS and Hanford

High-level liquid wastes at the SRS and Hanford are stored in carbon steel tanks that are susceptible to nitrate ion induced corrosion cracking. This is prevented by monitoring and maintaining adequate nitrite and hydroxide ion levels. At Hanford, the specifications for corrosion resistant levels of the OH^- and NO_2^- species depend on the NO_3^- levels. Therefore, sensors that could monitor all three species would be optimal to minimize the addition of inhibitor solution. Currently, this solution containing NO_2 and OH is added in excess causing more liquid to be introduced into the tank taking up much needed tank space and adding to the volume of waste that must eventually be retrieved and processed. Therefore, an increase in available tank space as well as a reduction in cost corresponding to the reduction in volume of waste requiring future processing would result if a $OH^-/NO_3^-/NO_2^-$ monitor could be used to control addition of inhibitor solution.

Path to Solution

- Evaluate commercial and other nondestructive examination systems to meet INEL's need for tank integrity inspection.
- Develop and deploy a Light-Duty Utility Arm (LDUA)-delivered end effector for nondestructive inspection in INEL's waste tanks.
- Identify and evaluate monitors for $NO_3^-/NO_2^-/OH^-$ to maintain corrosion inhibitor concentrations at Hanford.

FY97-99 Scope

Work activities to support INEL's need for tank integrity detection will include

- Evaluate availability of commercial or other "under development" nondestructive examination technologies to determine if mature systems are available to meet INEL's need.
- Develop a field deployable end effector for the LDUA system which that be used to perform nondestructive inspection of the INEL tank walls and knuckle region.
- Demonstrate and deploy the LDUA-delivered nondestructive examination system in an INEL waste tank for performance evaluation.

Work activities to support Hanford and SRS needs will include

- Evaluate the feasibility of commercial analyzers best suited for in-tank monitoring based on their range of detection, resistance to high radiation fields, reproducibility of measurement, and specificity.
- Conduct cold and hot testing of selected sensors.
- Validate sensor(s) performance and transfer for deployment.

Schedule

- Complete concept development and preliminary evaluation and selection of commercial nondestructive examination detection alternatives for development (FY98). ***Engineering Development***
- Place contract for end effector development/fabrication based on preliminary evaluation of commercial alternative (FY98). ***Engineering Development***
- Complete fabrication of end effector for nondestructive inspection (FY99). ***Engineering Development***
- Complete cold testing of the nondestructive inspection system (FY99). ***Demonstration***
- Perform in-tank demonstration and prepare engineering performance and cost data to support user decisions on full deployment (FY99). ***Demonstration***
- Complete evaluation of commercial $NO_3^-/NO_2^-/OH^-$ analyzers for in-tank monitoring (FY97). ***Engineering Development*** (RL06WT21-C)
- Conduct cold testing of corrosion inhibitor monitors and initiate hot demonstration (FY98). ***Demonstration*** (RL06WT21-C)
- Validate performance of $NO_3^-/NO_2^-/OH^-$ monitors and transfer for deployment (FY99). ***Implementation*** (RL06WT21-C)

Other Related Work

- TFA collaboration with Robotics on Nondestructive Inspection System (FY98)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA		150	300	200
Total		150	300	200

Problem Element Title: 1.1.1.2 Avoid Tank Corrosion

Problem Element Description

Tank leakage and structural failure is a critical concern during long- and short-term waste storage, as well as during retrieval operations and closure. Tank corrosion is the primary cause of steel waste tank failure. Passive or active methods for prevention of tank corrosion are encompassed within this problem element.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	601*	Hanford	Extension of Carbon Steel Tank Life and Minimizing the Impact of Processing
	601*	ORR	Extension of Carbon Steel Tank Life and Minimizing the Impact of Processing
	601*	SRS	Extension of Carbon Steel Tank Life and Minimizing the Impact of Processing
Secondary	169	INEL	Develop "Fly By" Nondestructive Inspection System
	382	SRS	Develop Real-Time Corrosion Monitoring Techniques

* Need developed by TFA for program and site benefit.

Problem Statement

Hanford, SRS, and ORR all have carbon-steel tanks with neutralized waste. All sites have reported leakage resulting from tank aging (corrosion). Tank leakage has occurred to a large extent in tanks that have not been heat treated. At Hanford, 67 out of 149 single-shell tanks are known or assumed to have leaked. Westinghouse Hanford Company analysis of the tanks show that a number of single-shell tanks will leak over the next 5 years. Success in prevention of corrosion, the major contributor to leakage, would prevent contamination of soil and provide sound for spare tank capacity. Corrosion in transfer lines at each site has been an safety issue as well as a transfer issue. Because all three site will need to continue tank to tank transfers, corrosion will continue to be an issue.

Path to Solution

- Evaluate the state-of-the-art in corrosion prevention relative to underground storage tanks.
- Develop performance specifications from site user input and identify the most appropriate providers of technology and services for future development.
- Develop advanced corrosion prevention methods based on user input to performance specifications.
- Demonstrate and evaluate methods for deployment at DOE sites.

FY97-99 Scope
Several small programs evaluating and identifying corrosion issues have been performed by DOE-HQ, NIST, Hanford, ORR, and SRS. Because there is potential for large cost savings, re-evaluation of the past efforts to determine if new efforts studying the corrosion of carbon-steel tanks in terms of techniques to extend life is beneficial. The effort would consist of

- Review of past program results and determination of what current work is being performed.
- Conduct a workshop involving the four waste tank sites to develop performance requirements for corrosion prevention and assess the status of active work in this area within government agencies, industry, and evaluation of any new work or increased effort that is cost effective.
- Issue procurement for advanced corrosion prevention technology to support enhancement of steel tank operating life.
- Demonstrate methods for corrosion prevention.
- Prepare engineering performance and cost analysis to support user decisions on deployment of steel tank corrosion prevention technologies.

Schedule
- Complete review and evaluation of past and current corrosion prevention development and deployment alternatives (FY97). *Engineering Development* (RL06WT21-A)
- Complete development of user-based performance specifications for corrosion prevention technology to support an FY98 call for proposals (FY97). *Engineering Development* (RL06WT21-A)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA		350	200	800
EM-50 Industry Program			600	
Total		350	800	800

Problem Element Title: 1.1.3.1 Characterize Waste In Situ

Problem Element Description

The baseline methods for characterization of tank wastes is to collect waste samples and perform laboratory analyses in a hot cell. In-tank or in situ characterization is highly desired as it could provide more rapid and cost-effective waste analysis. Characterization of tank waste physical, chemical, and radiochemical properties is required for planning and implementation of tank safety, retrieval, pretreatment, immobilization, and closure processes.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	486	INEL	In Situ Characterization Capability (Minilab)
	528	Hanford	Tank Closure Demonstration for an Arid Site
Secondary	541	Hanford	In Situ Core Drilling-Speciation

Problem Statement

The primary needs for in situ tank waste characterization have been identified by Hanford and INEL.

Hanford

To retrieve 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 at Hanford in the Recommendation 93-5 Implementation Plan[a] is to retrieve over 400 full-length cores. The 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 (i.e., from hot-cell analyses).

(a) U.S. Department of Energy Richland Operations Office (DOE-RL). *1994. Recommendation 93-5 implementation plan*. DOE/RL-94-01, U.S. Department of Energy Richland Operations Office, Richland, Washington.

INEL

At the INEL, a light-duty utility arm (LDUA) is scheduled for initial deployment in FY97. The LDUA will be used to deploy a variety of end effectors for visual inspection, waste sampling, and in situ characterization. Some of the INEL HLW tanks are scheduled for "cease use" by the year 2009 and the remainder by the year 2012. Characterization of the tank heels and residual waste or contamination may be required before the state and Federal agencies will grant closure permits. Data may be required on residual radionuclides, physical (e.g., particle size, viscosity, density, temperature, penetration force, depth), and chemical properties of the heel (e.g., organic compounds, acidity, oxidation potential, ionic species) to select appropriate heel retrieval technology or to reach agreement with the state on closure criteria for leaving the heel in place.

Path to Solution

- Develop and test a cone penetrometer system with Raman spectroscopy probe to detect major chemical components and tank moisture for Hanford tank applications.
- Deploy the cone penetrometer/Raman as part of the Hanford Tanks Initiative to support closure of Tanks 106-C and 104-AX at Hanford.
- Develop, test, and deploy a Minilab system for use on the LDUA for in-tank characterization of physical and chemical waste properties.

FY97-99 Scope

Hanford

During FY96, a 35-ton cone penetrometer platform with standard rheology sensors (sleeve friction and tip pressure), temperature sensor, and a bottom metal sensor was delivered to Hanford from Applied Research Associates, Inc (ARA). The commercial unit was also equipped with a prototype Raman probe, developed by Lawrence Livermore National Laboratory, which is designed to nonintrusively detect and map the vertical profile of major chemical components in tank waste sludge and saltcake such as nitrates, nitrites, ferrocyanides, phosphates, carbonates, etc. After deployment of the cone penetrometer into tank waste, the inside of the cone penetrometer pipe can be used as a dry well down which a neutron moisture sensor would be lowered to map the vertical profile of moisture in the tank waste. Continued work activities with the cone penetrometer/Raman system in FY97 and FY98 will include

- Preparation of an operations manual for the cone penetrometer/Raman including specifying the steps for in-tank measurements, establishing procedures for data reduction and generation of data reports.
- Conduct cold field test runs to train operators on the Raman spectrometer and cone penetrometer system.
- Increase the performance of the Raman probe through enhancements to the signal-to-noise ratio, upgrades on the first generation probe, and improvements to the data reduction software.
- Complete technology transfer to the Hanford Site users through development of field procedures, protocols for data collection and protocols for data reduction. The final product will be a bulk chemical sensor integrated into a commercial rheology package, with user friendly data reduction software, data collection and data reduction protocols, for deployment into highly radioactive tank waste.

INEL

A functions and requirement document for the INEL LDUA Minilab end effector has been issued (INEL-94/0202, 11/94). Work activities in FY98 and FY99 will include

- Fabrication of the Minilab based on the functions and requirements identified in 1996.
- Qualification of the Minilab for operation through testing in the Hanford LDUA cold test facility and provide training and documentation for INEL operators.
- Delivery and deployment of the Minilab at INEL for in-tank characterization activities.

Schedule

- Complete operations manuals and operator training for the cone penetrometer/Raman sensor system (FY97). ***Demonstration*** (RL07WT22-A)
- Complete upgrades to the Raman sensor to meet user specifications and enhance operator ease-of-use (FY97). ***Demonstration*** (SF26WT21-A)
- Complete technology validation, and transfer of the Raman sensor to the Hanford user (FY98). ***Implementation*** (SF26WT21-A)
- Complete fabrication and qualification of the Minilab for in-tank characterization at INEL (FY98). ***Engineering Development***
- Deploy the Minilab at INEL for radiation, physical properties, and chemical property mapping of heels in INEL HLW tanks. (FY99). ***Implementation***

Other Related Work

- Hanford Tanks Initiative - Gamma Probe, Depth Detection with the LDUA Gripper End Effector (RL07WT61-A1)
- Characterization End Effector for MLDUA (Robotics FY97)
- Neural Network for Improved Raman Response (CMST FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	575	450	250	
EM-50 Crosscutting Programs (CMST)	809	265		
EM-30/40 (Multiple Sites)	3,638	2,200	3,960	
Total	5,022	2,915	4,210	

Problem Element Title: 1.1.3.2 Sample Waste

Problem Element Description

Sampling of sludges, saltcake, and supernate from waste tanks is required to adequately characterize the physical, chemical, and radiochemical characteristics for adequate planning and implementation of safety, retrieval, pretreatment, and immobilization processes. Sampling of saltcake and hardened sludges is particularly difficult.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 530	Hanford	Off-Riser Sampling
Secondary N/A		

Problem Statement

Currently applied auger, push, and coring technology is limited to vertical tank sludge/saltcake sampling directly under available risers. Most tanks are limited to one or two risers for sampling, and installation of new risers may cost in excess of $1000K. Although any samples obtained from highly radioactive tank waste are considered invaluable for characterization data assessment, two vertical profile samples (1 inch in diameter) are insufficient to provide adequate samples for the horizontal profile of tank waste characteristics. If sampling methods could be developed to obtain off-riser samples from the available risers, this would provide the additional confidence in tank waste data that no large anomalies in waste composition or rheology exists between the below-riser samples. In addition, off-riser samples would provide a better statistical interpretation of tank waste data.

Path to Solution

- Assess feasibility of off-riser sampling.
- Procure industrial system.
- Cold test system with simulants.
- Demonstrate off-riser sampling in a waste tank.

FY97-99 Scope

- Complete assessment of the commercial feasibility of off-riser sampling. This work scope is planned by the Characterization, Monitoring, and Sensors Technology Crosscutting Program, and will provide input into TFA funding decisions for FY98.
- Design and procure an off-riser sampling system from industry.

- Conduct operations testing in a cold test environment to evaluate system operability and performance on simulated sludges and saltcake.
- Demonstrate off-riser sampling system in a hot waste tank at Hanford and produce engineering performance and cost data to support full-scale implementation decision.

Schedule

- Complete assessment of the feasibility of off-riser sampling (FY97). ***Engineering Development***
- Complete procurement and cold testing of commercial off-riser sampling system using simulated saltcake and sludge (FY98). ***Engineering Development***
- Perform demonstration of off-riser sampling in a Hanford waste tank and develop performance and cost data to support implementation decisions (FY99). ***Demonstration***

Other Related Work

- Off-Riser Sampling Tool (CMST FY97)
- Hanford Tanks Initiative Sampler for Tank Heel (RL07WT61-A1)
- Sampler demonstration under TFA TTP SR16WT51-A, Waste Retrieval and Closure Demonstration for Salt and Zeolite Heel Removal

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA		0	500	1000
EM-50 Crosscut Programs (CMST)		500	500	
Total		500	1000	1000

Problem Element Title: 1.1.3.3 Analyze Waste

Problem Element Description

Waste samples such as cores, supernate samples, and grab samples require hot-cell analysis to determine physical characteristics, chemical composition, and radionuclide concentration and speciation. Hot cell analysis of tank waste samples is expensive and time consuming.

Priority Site Needs

The FY95/96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 129	Hanford	Rapid Molecular, Elemental, and Radiochemical Analysis (FY95 Need)
Secondary N/A		

Problem Statement

The average cost to conduct a complete suite of physical and chemical analyses on a core of tank waste is about $350K and can take up to 200 days to complete. The high cost and long time periods required are partly due to the number of core segment subsamples that must be collected, homogenized, and dissolved before elemental analysis by conventional inductively coupled plasma/mass spectrometer or inductively coupled plasma/atomic emission spectroscopy methodologies. Development of remote analytical scanning technologies which can bypass these time and labor intensive steps and interrogate the solid samples directly are needed to reduce the cost, time, personnel exposure, and generation of secondary waste when characterizing solid radioactive core segments and samples from tank wastes.

Path to Solution

- Develop/adapt a commercial laser ablation/mass spectrometer for hot-cell applications.
- Conduct laboratory testing to verify instrument effectiveness.
- Deploy laser ablation/mass spectrometer system in hot cell and test with actual core samples.
- Improve operating procedures and data analysis software per user's requirements.
- Complete technology transfer to Hanford's analytical laboratory.

FY97-99 Scope

In FY96, the laser ablation/mass spectrometer system was designed and deployed into a hot cell in the Hanford 222-S Laboratory and used to measure elemental composition of actual tank waste. This was a collaborative effort in which funding resources from the EM-30 user were combined with the technology development funding provided by EM-50. Before the deployment: a) the system operating parameters including laser wavelength, pulse length, and pulse energy were established, b) initial laser ablation/mass spectroscopy method validation experiments including tests with cold standard samples and with actual TWRS waste samples were conducted, c) the laser ablation/mass spectrometer system control and data analysis operating software to support system assembly, testing, and initial routine operation was partially developed. (The software will provide necessary functions but it is expected that additional improvements will be developed based on operating experience) and, d) cold system assembly and testing of the new laser ablation/mass spectrometer to verify system operation and readiness for installation to the hot cell was completed. The technology gate achieved in FY96 was deployment and testing of the laser ablation/mass spectrometer on actual waste samples in a production facility. Scope of work for FY97 and 98 includes

- Continue software development to make the operation and data reduction capability of the laser ablation/mass spectrometer more compatible to an operator/production environment.
- Develop and validate a method for monitoring the ablation and feed rate of ablated aerosols to the inductively coupled torch part of the mass spectrometer.
- Complete technology transfer to the operators in Hanford 222-S Laboratory. This will include troubleshooting, software upgrade and operation manuals.

Schedule

- Complete software development and validation of the laser ablation/mass spectrometer elemental analysis methodology (FY97). ***Demonstration*** (RL36WT21-A)
- Complete full transfer of the technology to operators in a production environment for routine hot-cell application (FY98). ***Implementation*** (RL36WT21-A)

Other Related Work

- Automation of Hot Cell Analytical Techniques (Robotics FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	985	380	250	
EM-50 Crosscut Prog (Robotics, CMST)	2,210		1,400	
EM-30 Hanford	550	300		
Total	3,745	680	1,650	

Problem Element Title: 1.1.4.2 Reduce Recycle Streams

Problem Element Description

Secondary wastes such as contaminated water from offgas treatment systems are generated during the processing of tank wastes. Some of these streams are currently recycled to the tank farms due to their composition and lack of treatment trains that could allow release to liquid effluent treatment plants. Treatment of these waste streams would free tank storage spare and reduce life-cycle cost by reducing the volume of waste re-entering process plants.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 102	SRS	Concentrate Waste - Reducing Water Volume of Defense Waste Processing Facility
Secondary N/A		

Problem Statement

Start up of treatment processes produces additional recycle and secondary waste streams which must be additionally treated before release to the wastewater treatment process and discharge. An example is the 2,000,000 gal/yr Defense Waste Processing Facility (DWPF) stream which is recycled to HLW tanks and hence, added to future volumes to be treated. Technologies are needed to treat this moderately contaminated stream to prevent recycle to the full treatment process, which requires using expensive tank space and treatment processes developed for more highly contaminated waste.

Path to Solution

- Develop specifications and procure a commercial system for adaptation to the treatment of the DWPF recycle stream.
- Demonstrate the pilot system at SRS.
- Prepare engineering performance and cost data to support user decision on full-scale implementation potentially using the compact unit processing concept.

FY97-99 Scope

- Develop performance specifications for a modular treatment process to remove mercury and organics from the SRS recycle stream. A process will be developed and coordinated with waste treatment operations at SRS.

- Procure from industry the detailed design and fabrication of a pilot-scale treatment system. This demonstration unit will be modeled on the successful compact processing units demonstrated at ORR by the TFA in FY96 and FY97.
- Plan a demonstration to treat recycle water contaminated with radionuclides and hazardous wastes (mercury, organics), resulting in a stream which can be routed to the waste water treatment process.

Schedule

- Develop process specifications and coordinate needs and co-funding with the SRS Waste Operations team (FY98). ***Engineering Development***
- Initiate procurement of a detailed design for the treatment system (FY98). ***Engineering Development***
- Complete procurement of the demonstration system and prepare operational procedures (FY99). ***Demonstration***
- Complete DWPF recycle stream treatment demonstration (94,635.29 L [~25,000 gal]) (FY99). ***Demonstration***

Requested Budget

Funding Source	FY96 (SK)	FY97 (SK)	FY98 (SK)	FY99 (SK)
EM-50 TFA	350	0	500	1,000
EM-30/40 (SRS)	1,198			
Total	1,548	0	500	1,000

Problem Element Title: 1.2.1.1 Deploy Equipment

Problem Element Description

Radioactive waste storage tanks offer a significant challenge because of the difficulties in accessing the tank interior for inspection, waste characterization, retrieval, and closure. Safety issues and technical challenges drive the access difficulties. This problem element addresses methods for accessing the tank interior to enable inspection, characterization, retrieval, and closure devices to be deployed and operated. The description of the multiyear plan for this portion of the tank waste processing system has been divided into several sub-problem elements:

1.2.1.1.1 Deploy Equipment - Hanford
1.2.1.1.2 Deploy Equipment - ORR Gunite and Associated Tanks
1.2.1.1.3 Deploy Equipment - INEL
1.2.1.1.4 Deploy Equipment - Multi-Site System Development

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	528	Hanford	Tank Closure Demonstration for an Arid Site
Secondary	530	Hanford	Off-Riser Sampling
	363	INEL	Issues with Safe Operation, Decon, and Removal of Tank End Effectors
	445	INEL	Heel Waste Retrieval/Characterization - Light-Duty Utility Arm Deployment System
	187	ORR	Heel Waste Retrieval/Characterization -Light-Duty Utility Arm Deployment Systems
	64	ORR	Heel Waste Retrieval - Vehicle
	347	ORR	Heel Waste Retrieval - Waste Dislodging and Conveyance
	364	ORR	Issues with Safe Removal, Decon and Insertion of Retrieval Devices
	475	ORR	Tank System Closure Demonstration
	365	SRS	Issues with Safe Removal, Decon and Insertion of Retrieval Devices
	437	SRS	Tank Clean and Closure

Problem Statement

The primary mission of the Hanford Tanks Initiative (HTI) is to demonstrate the process for developing retrieval performance objectives with the regulators and stakeholders, demonstrating waste retrieval methods for hard heel waste, difficult waste forms, and those suitable for use in leaking tanks. This initiative supports the *Hanford Federal Facility Agreement and Consent Order* milestone M-45-00 to close al Hanford single-shell tanks by 2024 and lays the groundwork for the infrastructure and logistics to close single-shell tank operable units (tank farms). Tank 104-AX has been selected for the characterization and assessment of performance objective criteria because the residual waste volume may approach the *Hanford Federal Facility Agreement and Consent Order* compliance target of 10 m^3 (about 360 ft^3). Tank 106-C has been selected for the waste heel retrieval demonstration. The HTI is an EM-30 led project with the TFA providing technologies and assisting with the deployment of retrieval, characterization, and closure technologies, and modifying institutional barriers.

Tank 104-AX was selected as a prototype for the first single-shell tank closure demonstration because its waste has been removed by sluicing and the residual waste volume may approximate the *Hanford Federal Facility Agreement and Consent Order* compliance target of 10 m^3 (about 360 ft^3). The current historical estimate is that 7000 gal (26.5 m^3) remain in the tank. Based on supernate analysis, there may be large inventories of strontium-90 and cesium-137 (up to 5E+05 Ci), and up to 3.7 kg plutonium-239 remaining in the heel. Actual amounts will have to be determined by sampling and radiation surveys. The supernate samples also had significant amounts of mercury, a Resource Conservation and Recovery Act metal. Tank 106-C is scheduled for retrieval operations and will have its waste retrieved sufficiently for closure as part of the HTI. Specific problems and needs associated with retrieval and closure of tanks 104-AX and 106-C include

- Tank 104-AX sampling and survey requirements need to be determined.
- Deployment systems suitable for the sampling and survey tasks for Tank 104-AX need to be prepared for field use.
- The schedule for developing the sampling and sampling transfer tools is very aggressive. The scope must address sampling device handling and packaging design, shielding dose analysis review, and design, fabrication and testing.
- Hardness of heel is unknown and may challenge sampling.
- The Tank 106-C sampling requirements need to be determined for sample system selection.
- Deployment systems and sample equipment suitable to both chemical sampling and physical property determination for Tank 106-C need to be prepared for field use.
- Retrieval processes and deployment methods need to be identified and tested so the feasibility of using them in retrieving the hard heel in Tank 106-C can be determined. Tank 106-C rheological heel characterization data must be assessed against current simulants and adjustments in retrieval performance requirements made if needed.
- Safety analyses and long-term risk assessments have not been completed to provide stakeholders with background information to evaluate options.

Path to Solution
- Adapt the Light-Duty Utility Arm to support characterization for Hanford Tanks Initiative.
- Procure additional industry technology (i.e., deployment devices) and adapt, test, and evaluate for use in supporting characterization and retrieval activities.
- Deploy characterization tools to support closure of Hanford Tanks Initiative tanks.
- Deploy technology for retrieval of Tank 106-C heel.

FY97-99 Scope
Deployment devices and design support needed to deploy characterization and possibly retrieval tools in selected Hanford tanks will be provided. Alternative deployment devices will also be sought that are simpler than the Light-Duty Utility Arm and that will complement its capabilities.

It is anticipated, that the required end effectors are available for the Light-Duty Utility Arm if it is selected as a deployment method for the HTI. However, the Light-Duty Utility Arm will require modification and adaptation for these end effectors and for specific application within Tank 104-AX. Therefore, this activity will

- Modify the Light-Duty Utility Arm control system to support deployment in Tank 104-AX
- Procure and integrate sampling end effectors for the Light-Duty Utility Arm and perform integration tasks such as interface hardware, licensing and safety reviews. The Light-Duty Utility Arm with existing gripper end effector and appropriate sampling tools can be used to obtain sludge samples.

Work activities to characterize Tank 104-AX waste will

- Identify and procure additional deployment systems (such as a small ROV or reach rod) as necessary to cover the whole tank floor for visual inspection and extended sampling as well as closure operations.
- Deploy characterization tools using Light-Duty Utility Arm and/or other deployment systems to obtain residual waste samples and measure waste thickness. Before sampling, gamma mapping of the waste surface would be done to help develop a sampling strategy. The Tank Waste Remediation System at Hanford will attempt to establish closure criteria with the State by 1/97 and this criteria will provide the guidance in sampling and sample analysis strategy. For waste volume measurements, photographic, topographic mapping, and a penetrating probe for waste thickness will be used.

Work activities to characterize Tank 106-C and retrieve the heel after initial sluicing will involve similar efforts as defined above for Tank 104-AX. In addition, the Hanford Tanks Initiative will

- Characterize the heel rheology and chemistry for retrieval. It is anticipated that no further Light-Duty Utility Arm end effector development would be required for application in Tank 106-C after characterization of Tank 104-AX was completed.
- Test and demonstrate using industrial partners, retrieval methods from industry and the DOE complex, to support closure preparations of Hanford Tank 106-C. The TFA will provide support to HTI in technical design, specification development, and acquisition support in the area of deployment and retrieval processes. This task complements and enhances Acquire Commercial Technology for Retrieval activities in developing commercial contacts and performing equipment tests to evaluate commercial systems that could be used for heel retrieval.

Schedule

- Complete characterization of the Tank 104-AX heel to allow State regulators and DOE to reach agreement on tank retrieval performance requirements (FY97). ***Implementation***
- Complete a series of integrated tests of commercial and developed retrieval equipment to evaluate tools appropriate for the broad range of waste and tank conditions at the Hanford Site (FY97). ***Demonstration***
- Complete evaluation of deployment issues (i.e., hazards analysis, performance requirements) for characterization of Tank 106-C and deploy waste residue sampling/characterization equipment (FY97). ***Demonstration***
- Complete a series of cold tests on the proposed retrieval systems of the vendors that were selected to retrieve waste from Tank 106-C. These tests will demonstrate the systems that will be used in retrieving the hard heel in Tank 106-C (FY98). ***Demonstration***
- Complete adaptation of existing sampling and characterization tools for use in heel sampling for retrieval of Tank 106-C (FY98). ***Implementation***
- Complete integration of existing retrieval tools to the new deployment systems procured in FY97 for use in waste heel retrieval for Tank 106-C (FY98). ***Implementation***
- Complete adaptation of existing sampling and characterization tools for use in post-retrieval heel sampling for closure of Tank 106-C (FY99). ***Implementation***
- Deploy heel retrieval equipment in Tank 106-C. Complete retrieval of waste heel (FY99). ***Implementation***
- All of the above attributable to RL07WT61-A1, A3, A6, A9

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA		3,770	5,200	6,000
EM-30 (Hanford)				
Total		3,770	5,200	6,000

Problem Element Title: 1.2.1.1.2 Deploy Equipment - ORR Gunite and Associated Tanks

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 64	ORR	Heel Waste Retrieval - Vehicle
187	ORR	Heel Waste Retrieval/Characterization - Light-Duty Utility Arm Deployment Systems
347	ORR	Heel Waste Retrieval - Waste Dislodging and Conveyance
364	ORR	Issues with Safe Removal, Decon, and Insertion of Retrieval Devices
Secondary 365	SRS	Issues with Safe Removal, Decon, and Insertion of Retrieval Devices
475	ORR	Tank System Closure Demonstration
528	Hanford	Tank Closure Demonstration for an Arid Site

Problem Statement

Tank Closure Demo

As part of this closure demonstration, there is a need for a Light-Duty Utility Arm system to support the Gunite and Associated Tanks-Treatability Study. Specific requirements for the Light-Duty Utility Arm are

- visual inspection and placement of characterization/retrieval equipment
- retrieval of heels and other hard-to-remove wastes
- assisting in the removal of in-tank hardware
- decontamination of empty tank
- post-retrieval tank inspection and closure activities.

Path to Solution

- Complete development, delivery, and initial deployment of the modified Light-Duty Utility Arm at ORR.
- Transfer Light-Duty Utility Arm to ORR for full deployment in support of tank waste retrieval and closure.

FY97-99 Scope

LDUA Deployment

The FY97-99 work scope within this problem element will complete efforts begun in 1993 under the EM-50 Underground Storage Tank-Integrated Demonstration Program. During FY93-96, three Light-Duty Utility Arm systems were manufactured and delivered for use by the Hanford Site, INEL, and one system to remain in a cold test facility to support site users and continued applications development. Testing of the first unit deployed at Hanford was completed, and transition of this system to site users was initiated. Results of the baseline system test program (Problem Element 1.2.1.1.4) will be leveraged by ORR as the first step in qualifying the ORNL-modified Light-Duty Utility Arm for deployment in the gunite tanks. Work activities under this element will

- Complete delivery of the Modified Light-Duty Utility Arm to ORR from Spar Aerospace and provide technical support for deployment in gunite tanks.
- Complete integration and testing of the Modified Light-Duty Utility Arm with waste dislodging and conveyance technologies, confined sluicing end effector and balance of plant systems.
- Demonstrate waste heel retrieval in North Tank Farm gunite tanks.
- Produce engineering performance and cost data to support transfer of the Light-Duty Utility Arm technology for continued application to support remediation of gunite tanks, and to other DOE tank sites.
- Support in-tank industry demonstrations at ORR of candidate end effector technologies selected from cold testing at Hanford.

Schedule

- Deliver Modified Light-Duty Utility Arm to ORR and support initial deployment (FY97). ***Implementation*** (OR16WT51-A and RL07WT53-A3)
- Complete Light-Duty Utility Arm system integration, cold testing, and in-tank demonstration in gunite tanks (FY97). ***Implementation*** (OR16WT51-A)
- Complete transfer of Light-Duty Utility Arm system to ORNL in support of continued remediation work (FY98). ***Implementation*** (OR16WT51-A)
- Complete system upgrades and complete testing and integration of new end effectors as identified to meet ORR needs (FY98). ***Implementation*** (OR16WT51-A)
- Complete transfer of Light-Duty Utility Arm system to site user to support continued tank remediation efforts (FY99). ***Implementation*** (OR16WT51-A)

Other Related Work

- Houdini Vehicle Procurement (Industry Program FY97)
- Houdini Vehicle Testing (Robotics FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	450	900	750	450
EM-50 Crosscut Prog (Multiple)	1,075	2,075	800	
EM-40 (ORR)	4,130	2,500	1,750	
Total	5,655	5,475	3,300	450

Problem Element Title: 1.2.1.1.3 Deploy Equipment - INEL

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	169	INEL	Develop "Fly By" Nondestructive Inspection System
	363	INEL	Issues with Safe Operation, Decon, and Removal of Tank End Effectors
	445	INEL	Heel Waste Retrieval/Characterization - Light-Duty Utility Arm Deployment Systems
	486	INEL	In Situ Characterization Capability (Minilab)
Secondary	530	Hanford	Off-Riser Sampling

Problem Statement

At INEL, there is a need for a Light-Duty Utility Arm system to support characterization, safety, and retrieval functions. These include

- inspection of tank integrity
- characterization sampling of wastes and in situ waste analysis
- retrieval of heels and other hard-to-remove wastes
- retrieval of surveillance coupons
- closure activities.

Site requirements for the performance and design of this arm include

- The arm must be compatible with a variety of end effectors to perform functions listed above.
- All in-tank components of the system must be capable of operation in atmospheres which are highly corrosive, contain flammable gases, and have moderate radiation levels.
- The system must be deployed from ground level into underground storage tanks through existing tank risers with a diameter of 12 in.
- The system must be portable to allow use in multiple tanks and accommodate varying terrain or structural features found in the tank farm.
- The arm must provide dexterous manipulation capability to allow flexible positioning of end effector tools.
- The system must provide a functional operator interface and control modes which can be operated by trained operators and technicians.

- The system must meet all applicable tank farm operational requirements for personnel safety, contamination control, and apply as low as reasonably achievable principles.

Path to Solution

- Conduct acceptance testing and delivery of the Light-Duty Utility Arm to INEL.
- Demonstrate Light-Duty Utility Arm system performance and transfer technology to site operations.

FY97-99 Scope

The FY97-99 work scope within this problem element will complete efforts begun in 1993 under the EM-50 Underground Storage Tank-Integrated Demonstration Program. During FY93-96, three Light-Duty Utility Arm systems were manufactured and delivered for use by Hanford, INEL, and one system to remain in a cold test facility at Hanford to support site users and continued applications development. Testing of the baseline system deployed at Hanford was completed and transition of this system to the site user was initiated. Results of the baseline system test program (Problem Element 1.2.1.1.4) will be leveraged by INEL as the first step in qualifying the INEL Light-Duty Utility Arm for deployment in the Idaho Chemical Processing Plant high-level liquid waste tanks. Specific work activities within this problem element will

- Complete system acceptance testing and operator training for the INEL Light-Duty Utility Arm unit and prepare system for deployment at Idaho Chemical Processing Plant tanks.
- Complete development, fabrication and testing of required balance of plant equipment required to deploy the Light-Duty Utility Arm in the INEL tanks and complete system integration and testing; prepare for deployment.
- Complete end effector integration and testing for Minilab, Remote Viewing, sampling and nondestructive examination systems.
- Support industry demonstration at the Hanford cold test facility of candidate technologies for Light-Duty Utility Arm end effectors to address INEL's performance requirements.
- Complete in-tank demonstration of the Light-Duty Utility Arm system and transfer technology to site operations.
- Support fielded system with evaluation of new applications for Light-Duty Utility Arm and system upgrades.

Schedule

- Complete fabrication of Light-Duty Utility Arm and ship system to INEL (FY97) ***Engineering Development*** (RL07WT53-A4)
- Complete acceptance testing/training on INEL Light-Duty Utility Arm (FY98). ***Demonstration*** (RL07WT53-A4)
- Complete integration and testing of Light-Duty Utility Arm subsystems and on-site support systems. Light-Duty Utility Arm ready to deploy in Idaho Chemical Processing Plant tanks (FY98). ***Implementation***
- Complete industry end effector technology demonstrations (FY98). ***Demonstration***
- Complete initial in-tank deployment of Light-Duty Utility Arm in Idaho Chemical Processing Plant tanks and transfer LDUA to user (FY98). ***Implementation***
- Provide new end effector systems to support inspection and waste heel characterization (FY99). ***Demonstration***

Other Related Work

- Real-Time Nondestructive Examination End Effector (TFA/Robotics FY98)
- Minilab End Effector (TFA FY98)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	1,210	310	700	450
EM-30 (INEL)	550			
Total	1,760	310	700	450

Problem Element Title: 1.2.1.1.4 Deploy Equipment - Multisite System Development

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions.

Problem Statement

A review of the above extensive list of site needs points to an entire class of needed technology that must be obtained from industry, developed, adopted for tank use and implemented at one or more sites to enable characterization, safety, and retrieval equipment to be deployed within the tanks to meet operational requirements. These requirements include

- tank integrity and leak investigations
- characterization sampling of wastes and in situ waste analysis
- visual waste and tank inspection and placement of characterization or retrieval equipment
- tank mapping
- interim 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.

At three of the four HLW tank sites the Light-Duty Utility Arm system has been identified to support many of the characterization, safety, and retrieval functions. During FY93-96, three Light-Duty Utility Arm systems were manufactured and are being delivered for use by Hanford and INEL, while one system will remain in a cold test facility to support site users and continued applications development. Testing of the first unit delivered to Hanford was completed and transition of this system to the site user, Tank Waste Remediation System was initiated for a first deployment in a single-shell tank. Although the first system has been constructed and delivered, remaining technical needs include

- completion of technology transfer to operations of the Light-Duty Utility Arm Systems at Hanford, INEL, and ORR. Training of operators, shake-down testing and troubleshooting, integration of new end effectors, and testing of new sampling systems are required to support transfer and deployment of the Light-Duty Utility Arm at the three sites.

TFA Need Identifying No.	Site	Need Title/Description
Primary 445	INEL	Heel Waste Retrieval/Characterization - Light-Duty Utility Arm Deployment Systems
486	INEL	In Situ Characterization Capability (Minilab)
64	ORR	Heel Waste Retrieval - Vehicle
187	ORR	Heel Waste Retrieval/Characterization - Light-Duty Utility Arm Deployment Systems
347	ORR	Heel Waste Retrieval - Waste Dislodging and Conveyance
364	ORR	Issues with Safe Removal, Decon, and Insertion of Retrieval Devices
475	ORR	Tank System closure Demonstration
365	SRS	Issues with Safe Removal, Decon, and Insertion of Retrieval Devices
371	SRS	Develop Inspection Technologies for Type I and II Tank Annulus
431	SRS	Develop Method to Remove Mixed Salt and Sludge
432	SRS	Develop Method to Remove Dry/Hardened Sludge
435	SRS	Determine Zeolite Removal Requirements
602*	All	Develop Strategy, Requirement, and Needs for Deployment in Tanks
Secondary 528	Hanford	Tank Closure Demonstration for an Arid Site
530	Hanford	Off-Riser Sampling
532	Hanford	Instrumentation to Remotely Monitor Low (<5 wt.%) Waste Moisture Concentrations
162	INEL	Retrieval: Robotics Mixer Pumps, Waste Dislodging and Conveyance
363	INEL	Issues with Safe Operation, Decon, and Removal of Tank End Effectors
343	ORR	Bulk Sludge Mobilization and Slurry Transport - Mix and Mobilize Sludge
87	SRS	Manage Disposal of Tank Farm Failed Equipment
365	SRS	Issues with Safe Removal, Decon, and Insertion of Retrieval Devices

* Need developed by TFA for program and site benefit.

- Supervisory controls architecture and world modeling techniques to provide for safe operation and monitoring of the in-tank Light-Duty Utility Arm systems. Operating end effectors and data gathering require a fully functional operator interface and data archiving and display capability. Technical support and transfer of these systems to operations is required to fully implement supervisory control and data acquisition technologies.

In addition to the Light-Duty Utility Arm, discussions with site representatives confirmed the need for deployment tools that are more capable than present tank farm operational practice while less costly or complex than the Light-Duty Utility Arm. The functions that the sites need performed by this new class of deployment technology include

- insertion, removal and decontamination of retrieval, characterization and inspection tools
- technologies to inspect and retrieve tank annuli
- vehicles to supplement or replace other retrieval technologies.

Path to Solution

Light-Duty Utility Arm Deployment

- Complete transfer of the Light-Duty Utility Arm to Hanford, INEL, and ORR through shakedown testing, operator training, and troubleshooting as required.
- Integrate and test sampling and inspection end effectors and control systems to support site missions.

Deployment Systems

- Conduct mission studies to determine the varied site deployment technology needs and performance requirements.
- Review available industry technologies relative to the sites' performance requirements.
- Design development and test programs to evaluate commercial technology performance.
- Support site deployments of selected technologies that meet performance requirements.

FY97-99 Scope

Light-Duty Utility Arm Deployment

This technical task brings to fruition efforts begun in 1993 under the EM-50 Underground Storage Tank-Integrated Demonstration Program. During FY97 through FY98, efforts will be focused on transfer of the Light-Duty Utility Arm for implementation. Specific work activities will include

- Complete transfer to operations of the Light-Duty Utility Arm system at the Hanford and support operational use in co-funded arrangement with Tank Waste Remediation System.
- Sponsor series of industry demonstration of candidate technologies for Light-Duty Utility Arm end effectors to address above requirements.
- Support development of off-riser sampling system for Light-Duty Utility Arm to support the Hanford Tanks Initiative and other customers (jointly funded by Hanford Tanks Initiative/Tank Waste Remediation System).
- Provide technical support to Hanford and INEL in support of transferring Sandia National Laboratories provided supervisory control and data acquisition system technologies to site users. Support troubleshooting of fielded systems and system upgrades, including integration of new end effector systems.
- Provide technical support for improving operator interfaces, implementation of graphical control features, and improved capabilities for building and displaying the world model.
- Support interface to Robotics and Characterization, Monitoring, and Sensors Technology Crosscutting Programs to identify opportunities for demonstrating work in progress at the Light-Duty Utility Arm Cold Test Facility.
- Evaluate new applications for Light-Duty Utility Arm and system upgrades; support transfer of technology to new sites.

Deployment Systems

The TFA will prepare a detailed statement of work to cover this task and submit a call for proposals. The primary work activities will include

- Development of a formal, site coordinated strategy, requirements and needs for deployment in tanks.
- Development of a database of deployment technologies that exist in the industrial base.

- Conduct mission studies at each site citing deployment needs.
- Plan and conduct a series of deployment technology site demonstrations.

An initial assessment of site requirements and industry technology resulted in the identification of the borehole miner technology for specific application to retrieval of heels and other hard to remove wastes. This retrieval method incorporates an extendible nozzle that directs water to the waste in a similar fashion to past practice sluicing, but at higher pressures (up to 3,000 lb/in^2 as opposed to 300 lb/in^2) and at lower flow rates (150 gal/min as opposed to 300 gal/min). The nozzle can be deployed, extended over 10 ft, raised and lowered in elevation, as well as rotate about the vertical axis. This deployment capability allows operators to direct the energy of the waterjet more directly to break up waste. Specific work scope for the borehole miner will be performed by the Robotics Crosscutting Program in collaboration with the TFA and include

- Development of an elementary control system
- Investigating scaling parameters and costs for increasing the length of the nozzle extension.
- Assessing the ability to use the extendible nozzle for the SRS Tank 19 zeolite heel.

Schedule

Light-Duty Utility Arm Deployment
- Complete transfer of first Light-Duty Utility Arm to Hanford Operations (FY97). ***Implementation*** (RL07WT53-A)
- Complete testing and integration the topographic mapping system and nondestructive examination systems end effectors (FY97). ***Implementation*** (RL07WT53-A)
- Demonstrate enhanced operator interface and graphical controls (FY97). ***Demonstration*** (AL26WT51-B)

Deployment Systems
- Complete strategy for addressing site needs for new deployment systems (FY97). ***Engineering Development*** (RL06WT51-A)
- Complete initial testing and demonstration of new deployment systems (FY98). ***Demonstration*** (RL06WT51-A)
- Complete demonstration of deployment system improvements and selected full-scale equipment. (FY99) ***Demonstration*** (RL06WT51-A)

Other Related Work
- Deployment Tools/Systems (e.g., extendible nozzle) (Robotics FY97)
- Control System Upgrades for Light-Duty Utility Arm (Robotics FY98)
- In-Tank Survey of Metal Obstructions (CMST FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	6,540	2,290	3,050	3,200
Total	6,540	2,290	3,050	3,200

Problem Element Title: 1.2.1.2 Mobilize Bulk and Heel Wastes

Problem Element Description

Mobilizing bulk and heel wastes within a tank is required to remove materials for tank closure, for treatment, and for ultimate immobilization and disposal of the hazardous waste components. Mobilizing dense sludge, saltcake, and dry/hardened materials is particularly challenging and important for retrieval operations. Baseline methods for waste mobilization are mixer pumps and long-range, high water volume sluicing.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 534	Hanford	Waste Retrieval Methods Needed for Double-Shell Tank Waste Not Amenable to Advanced Design Mixer Pump Retrieval
535	Hanford	Single-Shell Tank Retrieval Equipment/Systems Development
575	Hanford	Simulant (Retrieval Process Test Material) Development
162	INEL	Retrieval: Robotics Mixer Pumps, Waste Dislodging and Conveyance
445	INEL	Heel Waste Retrieval/Characterization - Light-Duty Utility Arm Deployment Systems
185	ORR	Bulk Sludge Mobilization and Slurry Transport - Slurry Transport Studies
343	ORR	Bulk Sludge Mobilization and Slurry Transport - Mix and Mobilize Sludge
346	ORR	Bulk Sludge Mobilization and Slurry Transport - Alternative Mechanical Mobilization Systems
347	ORR	Heel Waste Removal - Waste Dislodging and Conveyance
375	ORR	Develop Simulants
421	SRS	Outline Mix Requirements and Pump Configuration for Salt Dissolution/Sludge Removal
422	SRS	Improve Salt Mining Equipment and Techniques
430	SRS	Develop Method to Address Insoluble Solids in Salt Tanks
431	SRS	Develop Method to Remove Mixed Salt and Sludge

TFA Need Identifying No.	Site	Need Title/Description
432	SRS	Develop Method to Remove Dry/Hardened Sludge
439	SRS	Develop Improved Slurry Pumps to Minimize Addition of Inhibited Water
487	SRS	Develop Simulants
Secondary 448	INEL	Retrieve Calcine from Bins

Problem Statement

The DOE complex has horizontal and vertical cylindrical waste storage tanks that require remediation. Removal of bulk saltcake and sludge, saltcake heels, hard sludge heels, and possibly debris will be required. In addition, at ORR, the gunite tanks have concrete linings that may require selective removal of contaminated concrete layers. Although the baseline means of mobilizing the sludges and other hard waste will be through hydraulic mining methods like sluicing or mixer pumps, alternative approaches are required for retrieval of the hard sludges, or bulk waste retrieval in leaking tanks where water use is restricted, as well as removal of debris and contaminated floor and wall segments.

Baseline retrieval process technologies (long-range sluicing or water monitors and mixer pumps) used at Hanford, SRS, and ORR have shortcomings that require improvement. For example, specific problems with mixer pumps include leaking seals that add too much water to tanks, high life-cycle costs, limited ability to mobilize heel wastes, creation of excessively dilute waste streams, and problems with operation in leaking tanks. Long-range sluicing, while effective, is still associated with large risks in terms of effectiveness for heel removal and safe use in leaking tanks. There is a strong need at all four sites (including INEL) to reduce retrieval activity programmatic risks by

- Improving overall processes to dislodge and convey a variety of wastes
- Developing or adapting locally deployed end effectors for site-specific application that can dislodge a variety of wastes, including hard sludge heels
- Developing or adapting better conveyance technologies to remove wastes from retrieved tanks
- Qualifying a suite of waste simulants and pedigrees 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 before actual site operations begin. Further, specific technical support is needed at SRS for the execution of the alternate retrieval technology selection of Phase III of the SRS retrieval and closure demonstration.

Path to Solution

- Deliver, deploy, and evaluate performance of the Confined Sluicing End Effector for waste retrieval at ORR.
- Demonstrate the light-weight scarifier for use at ORR as required for gunite tank wall cleaning/retrieval, and produce engineering performance data to support decisions at other sites.
- Develop, produce, and validate waste simulants for use in developing, testing, and qualifying waste retrieval processes.
- Conduct a waste removal and closure demonstration at SRS to assess alternatives for salt and zeolite heel removal (e.g., modified density gradient and sluicing via borehole miner).

FY97-99 Scope

Confined Sluicing

The overall scope of this work in FY97-99 is to provide Confined Sluicing End Effector equipment, based upon prototypic testing and detailed design to the site users. Specifically,

- The Confined Sluicing End Effector will be deployed in the ORR gunite tanks during FY97 after undergoing significant cold testing. During both the cold testing and the subsequent hot deployment, data will be gathered and used to determine the performance of the Confined Sluicing End Effector. These data will be used to improve the Confined Sluicing End Effector design, thereby improving the technical performance and reducing costs, and provided to the rest of the complex via a retrieval analysis tool. Some of the considered improvements include a nonrotating shroud, thus eliminating many operational challenges, nonrotating waterjets, eliminating the need for several seals and the electrical motor, thus significantly reducing cost.
- The testing and development of the INEL Confined Sluicing End Effector delivered in FY96 will be completed and closed out, and performance documented.

Light-Weight Scarifier

Baseline retrieval process technologies can be improved by adapting and enhancing proven processes like the light-weight scarifier to meet site needs in cases where hard heels and low water addition systems are beneficial. This technology is based on a ultrahigh pressure, low-volume waterjet cutter with a close coupled water scavenging system. Scope for this work activity will include

- Integrate and demonstrate the light-weight scarifier at ORR or another site to determine performance characteristics in a real tank environment.
- Develop retrieval models to predict the cost and efficiency of the light-weight scarifier as potential applications at Hanford and INEL and as compared to the Confined Sluicing End Effector.

Industry Technology Evaluation

In conjunction with DOE's international technology exchange program, the TFA will procure and evaluate additional industry and international technology to support the site needs in retrieval and mixing of tank wastes. Specific work activities will

- Continue to prepare and provide waste simulants to the sites and testing programs for evaluation of retrieval and mixing technologies. Evaluation of results of actual retrieval equipment performance will be compared to waste simulant tests to assess the validity of the simulant development efforts.
- Design, develop, and perform nonradioactive verification tests of Russian hydro monitor, hydro elevator, and pulsating pump on U.S. sludge simulants and actual wastes. Emphasis of testing will be on Hanford sludges.
- 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 joint Hanford and SRS mixer pump development project.
- Demonstrate pulsed air technology in a real tank environment.
- Conduct enhanced sluicing tests on simulants to provide options to all tank sites and provide a possible option for SRS in-tank 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 end user efforts.

Waste Retrieval and Closure Demonstration
The salt and zeolite heel removal demonstration at SRS will continue the demonstration and closure efforts associated with Tanks 41 and 19. In Tanks 41 and 19 in conjunction with EM-30 at SRS, the TFA will

- Complete the density gradient demonstration, single pump salt removal demonstration, and the modified density gradient method at SRS. The Phase I density gradient method demonstration will remove saltcake from its present 353-in. level to approximately the 293-in. level. At that point, the single pump salt removal demonstration will start which will carry the waste down the 155-in. level. The third phase of this demonstration will be the true modified density gradient method removing the salt from 155-in. level to approximately 36-in. level. The final 3 ft of salt and any residues on tank intervals will be removed by a waterjet. Data on cost and method efficiency will be developed and compared to the FY96 salt dissolution studies at Savannah River Technology Center.
- Install a borehole miner type extendible nozzle in SRS Tank 19 and mobilize the zeolite heel and waste heel, as necessary, for tank closure. With the support of Sandia National Laboratories, SRS will continue development of closure criteria and options in conjunction with their regulators and stakeholders (see Problem Element 1.3.1.3).

Schedule
Confined Sluicing
- Complete prototype testing of INEL's retrieval end effector and close out development efforts (FY97). ***Demonstration*** (RL36WT51-A)
- Assess engineering performance of ORR's Confined Sluicing End Effector after initial deployment (FY98). ***Demonstration*** (RL36WT51-A)
- Complete design and fabrication of a Modified Confined Sluicing End Effector for ORR after initial implementation of the Confined Sluicing End Effector in FY97 (FY98). ***Engineering Development*** (RL36WT51-D)
- Assess engineering performance of INEL's retrieval end effector after actual tank deployment (FY99). ***Implementation*** (RL36WT51-A)

Light-Weight Scarifier
- Complete preparation of the light-weight scarifier for integration at ORR (FY98). ***Demonstration***
- Assess engineering performance of the light-weight scarifier for continued use at ORR and other sites (FY99). ***Implementation***

Industry Technology Evaluation
- Complete simulant development and validation (i.e., "Pedigree") for the DOE complex (FY97). ***Engineering Development*** (RL36WT51-C)
- Complete initial Russian simulant tests and deliver equipment to U.S. for actual sludge testing (FY97). ***Engineering Development*** (RL06WT51-B)
- Complete pulsed air system testing and deployment recommendations (FY97). ***Demonstration*** (RL36WT51-B)
- Complete hot demonstration of Russian sludge retrieval equipment and evaluate engineering performance (FY98). ***Demonstration***
- Demonstrate commercial technologies for improved mixing and produce engineering performance data to support site decisions. (FY98). ***Demonstration***

Waste Retrieval and Closure Demonstration

- Complete salt removal in SRS Tank 41 and prepare engineering performance and cost analysis for alternatives evaluation (FY97). ***Implementation*** (SR16WT51-A)
- Complete removal of zeolite heel in SRS Tank 19 as needed. Demonstrate use of extendible nozzle technology for waste characterization (FY97). ***Implementation*** (SR16WT51-A)

Other Related Work

- Demonstration of Fluidic Diode Pump for Transferring Tank 41 Waste (International Program/AEA Technologies FY97)
- Mixing of Compacted Sludge in Horizontal Storage Tanks Using Fluidic Pulse Jets (International Program/AEA Technologies FY97)
- Controlled Recovery and Pumping of Sludge (International Program/AEA Technologies FY97)
- Technical Exchange Meeting (International Program/MINATOM FY97)
- Acquire Commercial Technologies for Retrieval (EM-30, Hanford)

Requested Budget

Funding Source	FY96 (SK)	FY97 (SK)	FY98 (SK)	FY99 (SK)
EM-50 TFA		5,050	4,850	2,300
EM-50 Industry Program			1,400	
EM-30/40 (Hanford)	1,320	1,000		
EM-30/40 (ORR)		3,000	1,000	
Total	1,320	9,050	7,250	2,300

Problem Element Title: 1.2.1.5 Detect and Mitigate Leaks

Problem Element Description

Tank leakage is a critical concern during long- and short-term waste storage, as well as during retrieval operations. This problem element covers the detection of leaks from storage tanks and the mitigation or repair of those leaks to prevent widespread contaminant migration. Baseline leak detection includes the use of dry wells, radiation sensors below tanks, and tank liquid level measurement. No baseline methods exist for leak repair or leak mitigation. Subsurface barrier technologies are an example of the types of mitigation methods that would fit within this problem element.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 347	ORR	Heel Waste Retrieval - Waste Dislodging and Conveyance
384	SRS	Develop Leak Repair Techniques
544	Hanford	Tank Leak Mitigation Systems
Secondary N/A		

Problem Statement

Both leak detection and mitigation or repair during retrieval operations was identified as high-priority needs for ORR, Hanford, and SRS. These needs are associated with both the near-term retrieval activities and the longer-term retrieval and storage of tank wastes that will occur over the next 10 to 15 years.

Leak Detection

Tank leakage during sluicing is possible for a number of reasons and could occur in the single-shell tanks at Hanford. The primary method for leak detection at Hanford will be a liquid level measure inside the tank, which has an accuracy on the order of thousands of gallons. Improved methods for leak detection are needed to prevent unplanned release of thousands of gallons of radioactive waste if a tank leak occurs during retrieval.

Leak Repair
Leakage during sluicing and other types of waste removal will be an issue with states, regulatory agencies, stakeholders, and sites. Two general types of leak prevention technologies exist: repair and mitigation. Both technologies need to be investigated and alternatives evaluated for support to future retrieval efforts. Success in this area could provide potentially large cost savings, meet agreements, and improve relations with the states.

Path to Solution

Leak Detection
- Demonstrate the electrical resistance tomography technology for leak detection at Hanford.
- Deploy electrical resistance tomography leak detection systems in conjunction with near-term retrieval operations at Hanford.

Leak Repair
- Evaluate state-of-the-art in leak mitigation and repair within DOE, U.S. industry, and internationally.
- Develop multiyear program to develop, test, and demonstrate systems for leak mitigation and repair based on user input on performance requirements and the current technology status.
- Prepare engineering performance and cost data to support sites' decisions on deployment of leak mitigation and repair technology.

FY97-99 Scope

Leak Detection
The TFA in conjunction with the Characterization, Monitoring, and Senors Technology Crosscutting Program has adapted a subsurface plume remediation monitoring technology to leak detection for radioactive storage tanks. By combining the electrical resistance tomography technique with the push-mode cone penetrometer technology, rapid and low cost deployment of leak detection systems is possible. The technology was cold tested in FY95 and FY96 at Hanford. Work activities in FY97 through FY99 will focus on deployment and adaptation of the electrical resistance tomography technology to meet Hanford and ORR needs. Specific work scope will include

- Develop a strategy for leak detection and monitoring during retrieval of potentially leaking tanks.
- Deploy the electrical resistance tomography around a selected Hanford tank to support potential leak determination during sluicing operations. Electrical resistance tomography would serve as the backup system for the in-tank liquid level measurements. Engineering performance and cost evaluation will be performed to support future deployment decisions on Hanford tanks.

Leak Repair
- Review and status the current state-of-the-art in leak mitigation technology within the DOE complex. For example, Westinghouse Hanford Company is currently investigating several leak mitigation technologies such as sheet barriers, close-coupled grout injection barriers, dry-air containment barriers; and leak minimization retrieval techniques. Status the tank waste site activities in this area and assess their needs and performance objectives.
- Investigate U.S. and foreign commercial leak repair and mitigation technologies and develop a technical panel to evaluate the technologies relative to the sites performance objectives
- Develop a program plan to address all of the site needs through development, testing, demonstration, and implementation. This plan and subsequent development and testing efforts will be coordinated with industry programs, the other focus areas, and the site users that have been involved in development, demonstration, and evaluation of subsurface barriers.

Schedule

Leak Detection

- Prepare leak detection and monitoring strategy for the Hanford Tanks Initiative (FY97). ***Engineering Development*** (RL07WT61-A4)
- Complete initial deployment of electrical resistance tomography technology for leak detection around a selected Hanford tank (FY98). ***Demonstration*** (RL07WT61-A4)
- Decision point on deployment of electrical resistance tomography in support of other Hanford tanks based on safety analysis and initial deployment of the technology (FY98). ***Gate 6*** (RL07WT61-A4)
- Deploy electrical resistance tomography technology at Hanford as appropriate (FY99) ***Implementation*** (RL07WT61-A4)

Leak Repair

- Complete initial assessment of DOE's past and current leak mitigation and repair activities (FY98). ***Engineering Development***
- Prepare program plan for leak mitigation and repair development and testing to meet site needs (FY98). ***Engineering Development***
- Initiate development and testing program for leak mitigation and repair (FY99). ***Demonstration***
- Provide site users with engineering performance and cost analysis to support decisions on deployment of leak mitigation and repair technology (FY 01). ***Implementation***

Other Related Work

- Electrical Resistance Tomography (CMST FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA		500	1,100	1,200
EM-50 Crosscut Prog (CMST)	500	490		
EM-50 Industry Program			600	
EM-30/40 (Multiple Sites)	494			
Total	994	990	1,700	1,200

Problem Element Title: 1.2.1.6 Monitor and Control Retrieval Process

Problem Element Description

Retrieval of tank wastes and transfer of the wastes between tanks and to processing facilities requires movement of highly variable mixes of solids and liquids through transfer piping. Monitoring and control of the wastes being transferred is necessary to ensure that pipeline flow is maintained. Solids settling, precipitation, or rheological property changes could result in pipeline plugging or failure if not monitored closely.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 528	Hanford	Tank Closure Demonstration for an Arid Site
555	Hanford	Real Time Waste Property Measurement System for Waste Transfer
345	ORR	Bulk Sludge Mobilization and Slurry Transport - In-Line Solids Monitoring
482	ORR	On-line Monitoring Waste Retrieval Process
Secondary N/A		

Problem Statement

Measurement of slurry density, viscosity, volume percent solids, and flow are required before and during transport of retrieved tank wastes to assure that the transport lines will not plug. The estimated cost to replace a plugged transport line at Hanford is $47M. Crucial parameters for maintaining a turbulent slurry flow and avoiding plugging due to excessive solids are a Reynolds number > 22,000, a specific gravity < 1.5, a viscosity < 30 cP, a volume percent solids <30, particle sizes of 0.5-4000 microns (with 95% of the total under 50 microns), and a design velocity of 6 ft/s. In situ tank and transport line sensors to measure slurry density, mass flow, viscosity, volume percent solids, and particle size distribution are needed.

Retrieval and transfer activities in need of near-term slurry monitoring include the gunite and associated tanks at ORR, and the Hanford tanks undergoing retrieval as part of the Hanford Tanks Initiative. For example, heel retrieval from Hanford Tank 106-C is planned in FY98 and the slurry will be transported over 1600 ft in a pipeline. ORR plans to conduct a cross-site slurry transfer of about 145,000 gallons of low radioactivity tank waste in FY98 through a 2-in. diameter transfer line. A downselect of the appropriate monitors, installment, and field testing of monitors is needed before FY98 to provide validated on-line slurry monitoring.

Path to Solution

- Develop and procure slurry monitors.
- Test and evaluate performance of slurry monitors relative to user-defined specifications.
- Deploy appropriate slurry monitors at ORR and Hanford to support users' retrieval schedules.

FY97-99 Scope

Under a current Westinghouse Hanford Company project W211, commercial slurry monitors are being tested for their ability to measure slurry transport parameters in-line to avoid plugging. The TFA and Characterization, Monitoring, and Sensors Technology are also sponsoring the development of slurry transport monitors.

In FY 96, research and development on an ultrasonic probe for monitoring volume percent solids and particle size distribution was conducted. Follow-on work scope will include:

- Comparative testing of the prototype ultrasonic slurry monitor against other commercial and noncommercial sensors. A test loop used for setting up standard slurry mixes and test conditions will be used to evaluate the relative performance of these sensors. This will be performed in conjunction with the Characterization, Monitoring, and Sensors Technology Program.
- Selection and deployment of the most appropriate sensors for ORR and Hanford will be made based on comparative testing. At ORR, a slurry monitor will be used during the cross-site transfer of gunite tank waste. At the Hanford Site, the slurry monitor would be installed for the heel removal project on the transport line from Tank 106-C.
- Validation of the slurry monitors will be made based on actual deployment at ORR and Hanford.

Schedule

- Complete function and requirements document for heel slurry transport monitors (FY97). ***Engineering Development*** (RL07WT61-A8)
- Evaluate and select slurry monitors for ORR and Hanford transfer and retrieval activities (FY97). ***Demonstration*** (RL07WT61-A8)
- Complete engineering modifications, as required, and deploy slurry monitors for heel retrieval and transfer monitoring (FY98). ***Implementation***

Other Related Work

- In-Tank or In-Line Sampling Device (International Programs/AEA Technologies FY97)
- In Situ Ultrasonic Reflection Coefficient Sensor to Measure Slurry Density In Tank and During Pipeline Transport (CMST FY97)
- In Situ Viscosity and Density Monitoring Using Quartz Resonators (CMST FY97)
- Ultrasonic Sensors for In Situ Monitoring of Physical Properties (CMST FY97)
- Neural Network Raman Cone Penetrometer Signal Extraction and Enhancement (CMST FY97)
- Ammonia Measurements in the Offgases (CMST FY97)
- Conduct Comparative Studies for Online Slurry Monitors (CMST FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	200	200	900	0
EM-50 Crosscut (CMST)	775	1,240	800	
Total	975	1,440	1,700	0

Problem Element Title: 1.2.1.7 Integrate Retrieval and Pretreatment Technology Systems

Problem Element Description

Waste retrieval and transfer operations are responsible for delivering a feed stream to the pretreatment operations that is of appropriate specifications to be processed effectively. Because waste characteristics, such as composition, volume, chemistry, rheology, vary significantly from tank to tank and site to site, the retrieval and transfer operations must be able to adjust retrieval processes to meet the specific tank requirements, and understand how these adjustments will impact the waste characteristics and pretreatment's feed specifications. This "interface" with pretreatment may include tools that predict the waste characteristics that will be achieved given tank waste data and the retrieval options available.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	594*	Hanford	Develop Strategy and Method for Managing Interface Between Functions
	597*	Hanford	Waste Handling at the Interface with Retrieval and Immobilization
	594*	ORR	Develop Strategy and Method for Managing Interface Between Functions
	597*	ORR	Waste Handling at the Interface with Retrieval and Immobilization
Secondary	N/A		

* Need developed by TFA for program and site benefit.

Problem Statement

Each site will be selecting retrieval and pretreatment technologies appropriate for their tanks' composition, volume, schedule, and regulatory environment. Tank waste characteristics are unique from site to site and tank to tank. A variety of processes and technologies might be applied to retrieval and treatment of these wastes. The TFA is compiling characterization data and developing and demonstrating retrieval, treatment, and immobilization technologies. However, a comprehensive methodology for matching the combination of technologies for a particular tank waste or blend of tank wastes is not available. Evaluation of alternative treatment options for a particular waste tank must consider the characteristics of the wastes (e.g., composition, volume, chemistry, physical properties, etc), the performance of available technology (e.g., cost, effectiveness), and the uncertainty in all of these factors. Moreover, closure criteria and the associated cost to meet these criteria must be considered as retrieval tools are selected. An integrated tool is needed to ensure users can reliably evaluate alternative processing approaches and system configurations and compare them based on multiple criteria.

Path to Solution

- Develop performance and cost tools for retrieval pretreatment processing to aid users in developing process flowsheets and to aid DOE in evaluation of proposals as privatization proceeds.
- Deploy process analysis tools on user-defined priority tanks to directly support decisions on the highest priority tanks.

FY97-99 Scope

- Compile data on tank waste characteristics and pretreatment processing performance. Chemical and performance data will be compiled and organized to ensure that the significant quantity of experimental data currently being obtained throughout the DOE complex on chemical processing (e.g., leaching/dissolution of tanks sludges) can be readily accessed.
- Assemble retrieval tool performance, tank geometry, and waste characteristic data needed for retrieval system selection in a database format.
- Model major pretreatment processes to allow performance predictions to be made under a variety of tank waste scenarios. A signification effort will be made to model aspects of the waste chemistry, such as solubility data, which needs to be made available to the process designers in a user-friendly form.
- Develop and prototype process analysis tool for selected site problems.
- Deploy process analysis tools on user-defined priority tanks.

Schedule

- Compile tank characteristics database and experimental and process demonstration performance data (FY97). *Engineering Development* (RL36WT51-E and RL06WT41-B)
- Develop initial technology models and initial prototype tool. Demonstrate on critical stream(s) identified by users (FY97). *Demonstration* (RL36WT51-E and RL06WT41-B)
- Complete prototype tool based on results of initial testing. Test tool with users on several priority tank waste streams (FY98). *Demonstration*
- Deploy process analysis tools for user-defined priority waste tanks. Update tool based on processing advancements from the TFA (FY99). *Implementation*

Other Related Work

- Acquire Commercial Technologies for Retrieval Program at Hanford (EM-30 FY96/97)
- Development of a Cesium Removal Technology Handbook (ESP FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	300	600	600	200
Total	300	600	600	200

Problem Element Title: 1.2.2.1 Calcine Waste

Problem Element Description

Calcination is the baseline technology for solidifying liquid HLW and storing it as a granular solid in underground stainless steel bins within concrete vaults at INEL. This problem element addresses technology development to modify the calcination operating parameters to make them compatible for calcining radioactive liquid waste high in sodium and development of a particle analyzer to monitor elemental composition of fines in the calciner offgas.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 501	INEL	Alternative Calcination Process Flowsheet
502	INEL	On-Line Process Monitor for Elemental Analysis of Calcine Product
Secondary N/A		

Problem Statement

Based on a Settlement Agreement with the State of Idaho, the INEL must "cease use" of all HLW tanks by 2012. About 1.5 million gallons of existing and an additional 1.4 million gallons (projected) of sodium-bearing radioactive waste must be converted to calcined waste particles and pneumatically transported to the underground storage facilities before compliance with the "cease use" agreement is obtained. The sodium-bearing waste is not compatible with the current fluidized bed calcination flowsheet at 500°C because of incomplete conversion of the nitrates to oxides and the formation of agglomerated particles in the calcine. Alternative flowsheets that use sugar and/or higher calcination temperatures are under development with an objective to provide full-scale calciner operating parameters by September 1999 and begin equipment modifications on the calciner in January 2001. The process monitor will be used to assure offgas calciner fines and the calciner product does not exceed safety limit criteria for total organic carbon content and to monitor the product consistency of other elements.

Processing

The alternatives to be considered include high temperature processing and sugar additive calcination to improve denitration, thereby eliminating agglomeration problems caused by excessive sodium and potassium nitrates. A thermal denitration method has been developed and tested in the laboratory using waste simulants. The resulting solid materials have been incorporated into acceptable grout forms. This high-temperature (650°C) process generates a large volume of corrosive (acidic) offgas, with a high concentration of NO_x. The resulting solid may vary from a free-flowing powder to a caked solid. Further process development is needed to ensure that there is an adequate basis for the required plan and schedule.

Process Monitoring

Process control monitoring to detect process upset conditions or out-of-specification combinations of compounds will be needed. Development of real-time process control monitoring will be needed to 1) measure hydrocarbons (as elemental carbon) in calcine offgas fines and 2) measure elemental species in the calcine product (sodium, aluminum, iron, calcium, fluoride, potassium, and Resource Conservation and Recovery Act metals).

Path to Solution

- Develop methods to denitrate sodium-bearing waste before calcination to reduce gas load and NOx release.
- Adapt and demonstrate a laser-induced breakdown spectrometer for on-line process monitoring.

FY97-99 Scope

Processing

- Develop a process flowsheet, specifications for process equipment, and test prototype system for thermal denitration.
- Perform demonstration testing based on the FY97 results to support the full-scale design team with engineering performance and cost data.

Process Monitoring

The laser-induced breakdown spectrometer has been identified by the user as a potential on-line real time instrument capable of monitoring elemental and carbon composition of fines and calcine at high temperature. Development of laser-induced breakdown spectrometer has been sponsored by the DOE at Mississippi State University and at Sandia National Laboratories. Specific work scope would include

- Adapt existing laser-induced breakdown spectrometer instrument for testing with the high-temperature fluidized bed calcination process.
- Demonstrate the laser-induced breakdown spectrometer system at INEL on the pilot-scale calcination process and provide performance data to support decision on deployment.

Schedule

Processing

- Complete laboratory-scale tests with simulated low-activity waste to establish optimum operating parameters for the high-temperature flowsheets (FY97). ***Engineering Development*** (RL06WT31-D)
- Develop process equipment specifications for thermal denitration (FY97). ***Engineering Development*** (RL06WT31-D)
- Complete performance specifications for full-scale thermal denitration based on pilot-scale testing (FY98). ***Demonstration***

Process Monitoring

- Establish feasibility, sensitivity, accuracy, and calibration of laser-induced breakdown spectrometer for on-line monitoring (FY97). ***Engineering Development*** (RL06WT21-B)
- Adapt and demonstrate the laser-induced breakdown spectrometer during pilot-scale process testing at INEL (FY98). ***Demonstration*** (RL06WT21-B)

- Complete demonstration of the laser-induced breakdown spectrometer process monitor and report on engineering performance and cost to enable INEL to decide upon installation into the full-scale hot facility before the year 2001 (FY99). *Demonstration*

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	0	600	650	500
EM-30 INEL	2,835	2,745	2808	2,680
Total	2,835	3,345	3,458	3,180

Problem Element Title: 1.2.2.3 Prepare Retrieved Waste for Transfer and Pretreatment

Problem Element Description

Between the waste retrieval and transfer operations and the pretreatment operations occurring during tank waste remediation, a processing step exists in which retrieved materials such as sludge, saltcake, and supernate will need to be prepared for processing. The pretreatment facilities will require feed streams that can be adequately transferred through pipelines without plugging and that are compatible (e.g., density, solids content, rheology, particle size, blending reactions) with pretreatment unit operations. This "interface" with retrieval and transfer may include processing to adjust sludge, supernate, or saltcake properties through blending, additives, dissolution, etc.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	421	SRS	Outline Mix Requirements and Pump Configuration for Salt Dissolution/Sludge Removal
	528	Hanford	Tank Closure Demonstration for an Arid Site
		INEL	
	185	ORR	Bulk Sludge Mobilization and Slurry Transport - Slurry Transport Studies
	343	ORR	Bulk Sludge Mobilization and Slurry Transport - Mix and Mobilize Sludge
	364	ORR	Issues with Safe Removal, Decon, and Insertion of Retrieval Devices
Secondary	N/A		

Problem Statement

Two primary issues exist within this problem element that have the potential to significantly impact baseline processing at Hanford, SRS, and ORR. These issues include 1) sludge and saltcake chemistry and its impact on dissolution rates, pipeline transfers, and mixing operations, and 2) sludge physical properties and their impact on the pipeline transfer and mixing operations.

- Waste Conditioning Requirements for Heel Transfer of 106-C At Hanford, SRS and ORR, the sludge and hard heel retrieval rates, which are influenced by the chemistry/speciation of sludges, may be too slow for the proposed processing schedule. Furthermore, the chemistry of the slurry from the sludge retrieval process may need to be adjusted to prevent plugging of transfer lines and other operational problems. In addition, the mixing of the heel from one tank (e.g. 106-C as part of the Hanford Tanks

Initiative) with the slurry or heel of another tank must be done so that the mixture is compatible. The influence of the retrieval and transfer processes on downstream waste pretreatment operations, such as enhanced sludge washing at Hanford, must be understood to avoid adverse impacts on operations and performance. Information is needed on conditioning requirements, speciation, and design envelopes of acceptable compositions for processing and mixing. Assistance to the retrieval team in preventing or solving problems with retrieval and transport is also needed.

- Physical Properties Affecting Waste Transfer Tank waste has aged for several decades, and solids of various sizes have formed that must be retrieved and treated. How the solids are mobilized, reduced in size, transferred, and treated will have an impact on the overall cost and viability of the retrieval and downstream pretreatment processes. There is a need to investigate the impact of large particle transport, develop performance specifications for acceptable sludge properties, and conduct an engineering evaluation on potential in-tank size reduction techniques before transport for these dry/hardened sludges.

Waste Conditioning for Transfer of Dry/Hardened Sludges

- Contents in several tanks at SRS and Hanford have exposed sludge that has been allowed to dry or see elevated temperatures. Studies to date have been on sludges that have not dried. The effects of drying and high temperature on the physical and chemical properties has not been investigated. For example, does drying and/or high temperature change the rheological properties of sludge such that when water is added to retrieve the waste it will not disperse? Also, does the crystallinity of the solid phases change (e.g., gibbsite-to-boehmite ratio which would affect aluminum dissolution)? This information is necessary to ensure sludge retrieval and washing can proceed as designed. If not, alternate methods must be developed.

Path to Solution

- Establish a testing program on Tank 106-C soft and hard sludges. Obtain critical chemical and physical properties that influence the bulk waste transport properties. These include viscosity, particle size, and shape (as measured by fractal dimension), particle density and solids concentration as well as pH, gel formation potential, ionic strength, and presence of surfactants.
- Evaluate sludge physical properties affecting waste transfer and develop performance specifications for acceptable waste physical properties.
- Conduct studies with dry, hardened SRS sludges to evaluate their physical and chemical properties, and develop alternative approaches as needed for effective sludge processing.

FY97-99 Scope

- Conduct tests on Tank 106-C that have been subjected to conditions that simulate the mechanical and hydraulic mobilization of sludge to determine performance specifications and information for the Hanford Tanks Initiative user.
- Explore conditions which alter critical chemical and physical properties that influence the bulk waste transport properties. Examine conditions under which waste will precipitate or otherwise change to plug transport lines.
- Collect and characterize samples of tank waste from Hanford for particle size, hardness, and rheology.
- Perform simulant studies for rheological properties in transfer lines (Florida International University).
- Conduct aging studies on simulated SRS sludges to evaluate physical property changes.
- Conduct laboratory-scale sluicing and dissolution studies on actual dry, hardened SRSs sludge samples.

Schedule

- Complete laboratory tests on Tank 106-C sludge heel transport (FY97). ***Engineering Development*** (RL07WT61-A7)
- Evaluate potential waste conditioning methods that could be employed for retrieval and develop performance specifications (FY97). ***Engineering Development*** (RL07WT61-A7)
- Complete bench-scale tests of conditioning methods for Tank 106-C sludges (FY98). ***Engineering Development***
- Select and demonstrate industry technology for size reduction and transport enhancement using simulants (FY99). ***Engineering Development***
- Conduct demonstrations on size reduction and transport enhancement using actual wastes (FY99). ***Demonstration***
- Perform aging studies on simulated SRS sludge and obtain dried sludge sample for hot testing in FY99 (FY98). ***Exploratory Development***
- Complete sluicing and dissolution studies on actual SRS hot wastes (FY99). ***Advanced Development***

Other Related Work

- Chemical and Physical Properties Affecting Slurry Rheology (FIU FY97)
- Sludge Storage Modeling (International Programs/MINATOM FY97)
- In-tank Grinder for Solids Size Control (Industry Program FY97)
- Slurry Processing (ESP FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA		400	1,150	1,700
EM-50 University Programs (FIU)				
Total		400	1,150	1,700

Problem Element Title: 1.2.2.4 Clarify Liquid Stream

Problem Element Description
Liquid wastes retrieved from storage tanks require clarification (i.e., filtration, centrifugation, decanting) to remove suspended solids such as sludges or precipitates that may interfere with downstream processing.

Priority Site Needs
The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	97	SRS	Late Wash Precipitate - Clarification of Liquid Streams
	563	Hanford	Demonstrate Filtration for Pretreatment Solid-Liquid Separations
	9	INEL	Removal of Undissolved Solids from Tank Waste and Dissolved Calcine
	176	ORR	Liquids-Solids Separations Studies

Problem Statement
The priority need for solid-liquid separation was identified by the four primary tank sites as a critical problem.

SRS has a decade of experience designing, testing, and operating solid-liquid separation for in-tank precipitation; however, this technology is not directly applicable to all of the solid-liquid separation problems at the four sites. For example, at ORR, treatability studies performed indicate that standard clarification/filtration equipment will not be adequate. Testing of alternative filter systems is required to support the separation of undissolved solids from the sodium-bearing and dissolved calcine wastes at INEL, the late wash precipitate at SRS, various liquid LLW streams at ORR including TRU sludges, and strontium/TRU-bearing retrieval solutions, supernatants and wash solutions for phase I privatization at Hanford. At INEL, if the undissolved solids are not adequately removed, the solvent extraction and ion-exchange processes used for TRU, cesium, strontium, and technetium separation will have a high probability of failure. Separation of fine solids and colloidal particles from Hanford supernates is required to assure that the low-level waste stream will have acceptably low concentrations of insoluble radioactive material, principally strontium and TRU radioisotopes. At ORR, solid-liquid separation will be needed during the gunite and associated tank retrieval demonstration to treat excess sluice water for disposal, to concentrate tank sludges for feed to a treatment process, or reduce volume of retrieved sludges before transfer to interim storage tanks in the ORR active waste system.

Path to Solution

- Identify industrially and internationally available enhanced filtration systems to meet multisite needs.
- Perform laboratory- or bench-testing of advanced filters with simulated wastes.
- Deliver bench-scale filter systems to the sites for hot testing.
- Provide technical support to sites in selection and testing of full-scale filter systems.
- Conduct full-scale demonstration on solid-liquid separation at ORR as part of Gunite and Associated Tanks-Treatability Study.

FY97-99 Scope

- Complete testing for Hanford Tank Waste Remediation System of radioactive wastes using the Cells Unit Filters at Hanford.
- Complete demonstration of crossflow filtration unit during Gunite and Associated Tanks-Treatability Study at ORR.
- Construct and test a Cells Unit Filters unit designed for remote radioactive service at INEL. Demonstrate regeneration options in cold and hot bench-scale testing for acidic wastes.
- Continue testing of commercially available filters identified in FY96 on laboratory-scale equipment with simulated wastes to support filtration of the SRS Defense Waste Processing Facility recycle.
- Conduct side-by-side testing of U.S. and Russian separation technology to evaluate merits of international technology transfer.
- Conduct full-scale solid-liquid separations on retrieved sludges from gunite tanks.

Schedule

- Perform filtration benchmark testing in conjunction with the gunite and associated tank heel removal demonstration, and Hanford Tank Waste Remediation System (FY97). ***Demonstration*** (OR16WT41-A, RL36WT41-D)
- Complete gunite and associated tank demonstration of solid-liquid separation technology (FY97). ***Demonstration*** (OR16WT41-A)
- Complete radioactive sludge filtration testing on actual Hanford wastes. Support development of the overall tank waste pretreatment flowsheet (FY97). ***Demonstration*** (RL36WT41-D)
- Deliver a Cells Unit Filter to INEL and complete initial testing of calcine and sodium-bearing waste pretreatment (FY97). ***Demonstration*** (ID76WT41-A, SR16WT41-C)
- Complete simulated waste testing of commercial filtration systems in support of Defense Waste Processing Facility recycle (FY97). ***Demonstration*** (SR16WT41-C)
- Test Russian technology on U.S. waste streams for improved solid-liquid separation (FY98). ***Demonstration***
- Complete decommissioning and performance reporting of the gunite and associated tank demonstration system (FY98). ***Demonstration***

Other Related Work

- Engineering Scale Crossflow Filtration Demonstration (International Programs FY97)
- Solid-Liquid Technology Demonstration (International Programs/MINATOM FY97)
- Reusable Cartridges for Solid-Liquid Separations (Industry Program FY97)
- Magnetic Seed Filtration (ESP FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	1,183	1,400	250	400
EM-30/40 (Multiple Sites)	1,628	394		
Total	2,811	1,794	250	400

Problem Element Title: 1.2.2.5 Remove Radionuclide

Problem Element Description
Radionuclide removal from tank waste supernate is a primary requirement at all of the DOE waste tank sites because the presence of radionuclides directly impacts the waste immobilization decisions and the volume and cost of LLW and HLW generated. The primary radionuclides of concern are cesium, strontium, technetium, and TRU. Removal processes for these radionuclides include in-tank, at-tank (compact processing), and out-of-tank (processing facility unit operations) which separate and concentrate the radionuclides of concern. The description of the multiyear plan for this portion of the tank waste processing step has been divided into several sub-problem elements:

1.2.2.5.1 Cesium Removal from Alkaline Wastes
1.2.2.5.2 Radionuclide Removal from Acid Wastes
1.2.2.5.3 Technetium Removal from Alkaline Wastes
1.2.2.5.4 Other Radionuclides Removal from Alkaline Wastes

Problem Element Title: 1.2.2.5.1 Cesium Removal from Alkaline Wastes

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	519	SRS	Evaluate Ion Exchange or Precipitation Methods to Selectively Remove Cesium from High Potassium Salts
	562	Hanford	Demonstrate Cesium Removal for Hanford Supernatants
	489	ORR	Liquid LLW Supernatant
Secondary	N/A		

Problem Statement

Cesium removal from alkaline wastes is a baseline requirement at SRS, ORR, and Hanford to allow the resulting wastes to meet LLW acceptance criteria, and to reduce the future radiation exposure to personnel and the environment. Specific problems associated with cesium removal are as follws.

SRS

At the SRS, cesium must be removed from supernates before grouting. In-tank precipitation is the baseline cesium removal process used at the SRS. The in-tank precipitation involves adding sodium tetraphenylborate to the supernate in the tank. After the cesium reacts with the sodium tetraphenylborate, the resulting tetraphenylborate precipitates out of the supernate. Unfortunately, the in-tank precipitation operations at the SRS have recently been suspended because nearly all of the soluble sodium tetraphenylborate in Tank 48 decomposed. As a result of this decomposition, hundreds of kilograms of benzene were released to the head space of the tank, resulting in a safety concern. Flowsheet changes are being tested at SRS to resolve this issue. Alternative cesium removal technologies are desired for SRS as a backup to the baseline in-tank precipitation process and to allow potential improvements in efficiency and life-cycle costs.

ORR

Cesium removal using crystalline silicotitanate has been identified and tested as an improved method for cesium removal at ORR. However, this method has not yet been demonstrated at a full scale using radioactive wastes from ORR. Performance and cost data from actual processing is needed to ensure that deployment of this improved baseline is appropriate.

Hanford

Hanford is required to treat supernate to remove cesium to ensure that the resultant waste meets waste acceptance criteria. Past activities have been focused on Class C waste acceptance criteria. Therefore, there is a need to ensure that technology can meet the more stringent removal requirements. Flow studies on various actual Hanford wastes is required to provide cost and performance data on different waste stream compositions to the privatization contractor.

Path to Solution

- Complete demonstration and transfer the crystalline silicotitanate compact processing system for use on cesium at ORR.
- Conduct laboratory- and bench-scale tests on a variety of sorbents and waste types at SRS and Hanford to develop performance and cost data. Leverage with Efficient Separations and Processing Crosscutting Program.
- Demonstrate an alternative process for cesium removal at SRS to allow efficient and safe operations while reducing the life-cycle costs.
- Provide engineering performance and cost data on cesium separation alternative to Hanford and SRS for decisions on baseline cesium separation.

FY97-99 Scope

- Complete demonstration and reporting on crystalline silicotitanate removal of cesium at ORR. The demonstration will be continued into FY97 from FY96. The system will be transferred to Waste Operations at ORR for deployment.
- Conduct bench-scale tests on six Hanford waste tank supernates with two cesium-removal sorbents to evaluate the sorbents' effectiveness at meeting waste acceptance criteria on a range of waste types.
- Conduct batch tests with granular crystalline silicotitanate from UOP on several SRS supernates. The amount of crystalline silicotitanate that must be added to the tanks to meet the required cesium decontamination factors will be determined. The impact of crystalline silicotitanate on the amount of HLW glass that must be generated will also be evaluated. The task will also determine if the same procedure and equipment that is used for in-tank precipitation can be used with crystalline silicotitanate.
- Perform bench-scale column studies with crystalline silicotitanate on SRS supernates to provide the engineering and cost estimate necessary to allow an evaluation of column treatment for SRS.
- Demonstrate in-tank or out-of-tank processes (depending on FY98 results) for improved cesium removal at SRS.

Schedule

- Complete demonstration and transfer of compact processing unit using crystalline silicotitanate technology to waste operations for implementation at ORR (FY97). ***Implementation*** (OR16WT41-C)
- Conduct flow tests with wastes from Hanford tanks and report on sorbent performance for cesium removal (FY97). ***Engineering Development*** (RL07WT42-A)
- Prepare engineering and cost analysis data from Efficient Separations and Processing Crosscutting Program and TFA results on the performance of in-tank and out-of-tank crystalline silicotitanate processes with SRS waste streams (FY98). ***Engineering Development***
- Demonstrate a new in-tank or compact processing unit cesium removal technology on actual waste at the pilot-scale at SRS (FY99). ***Demonstration***
- Validate cesium removal engineering performance for Hanford wastes (FY99). ***Demonstration***

Other Related Work

- Development of a Cesium Removal Technology Handbook (ESP FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	2,030	1,540	1,900	1,750
EM-50 Crosscut Prog (ESP)	1,484	750	730	
EM-30 (ORR)	1,000	1,000		
Total	4,514	2,290	2,630	1,750

Problem Element Title: 1.2.2.5.2 Radionuclide Removal from Acid Wastes

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 247	INEL	Removal of TRU, Strontium, Technetium, Cesium from Tank Waste and Dissolved Calcine
Secondary N/A		

Problem Statement

Removal of TRU elements including strontium, technetium, and cesium from INEL waste streams by solvent extraction has been selected as the baseline approach for liquid tank waste produced after 2015 and the current HLW calcine inventory. Treatment technologies applicable to these radionuclides must be developed and tested to provide cost and performance data for final baseline technology selection.

Path to Solution

- Select appropriate separations processes for TRU, technetium, strontium, and cesium removal.
- Test and demonstrate methods for TRU, technetium, strontium, and cesium removal over a 3-year period.
- Produce performance and cost data to support INEL decision on their baseline radionuclide separation unit operations.

FY97-99 Scope

This is a 3-year effort to demonstrate several separation operations. In FY96, TRU solvent extraction was conducted to remove TRU elements and technetium. Efforts in FY97 and FY98 will include

- Demonstrate strontium removal on actual tank waste using the countercurrent SR extraction flowsheet.
- Evaluate performance of calcine dissolution at the bench-scale and demonstrate TRU extraction on dissolved calcine.
- Demonstrate cesium removal using sorbents and processes identified in FY97, and produce engineering and cost data to support agreements.

Schedule

- Complete countercurrent testing of strontium extraction process with actual tank waste (FY97). *Demonstration* (ID76WT41-B)

- Complete countercurrent testing of TRU extraction process on actual dissolved calcine (FY98). *Demonstration*
- Complete bench-scale calcine dissolution and cesium sorbent testing on actual tank waste (FY98). *Demonstration*

Other Related Work

- This work is cofunded with Efficient Separations and Processing Crosscutting Program.

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA		550	550	
EM-50 Crosscut (ESP)	890	450	420	
Total	890	1,000	970	

Problem Element Title: 1.2.2.5.3 Technetium Removal from Alkaline Wastes

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 533	Hanford	Technetium Removal
Secondary 495	ORR	Strontium, Technetium, and Ruthenium Removal

Problem Statement

To meet performance requirements for the LLW form at Hanford, technetium must be removed from the supernate in select tanks before immobilization. A decontamination factor of 10 will be needed for the technetium in Tank 101-AZ, which contains neutralized current acid waste. Other types of supernates that are expected to require technetium removal are double-shell slurry feed, concentrated phosphate waste, dilute noncomplexed waste, complexant concentrate waste, and dilute complexant concentrate waste. In addition, the previous assumption that all of the technetium in the supernates is in the form of pertechnetate has been proven to be incorrect. Hence, anion exchanges are less effective if non-pertechnetate forms of technetium are in solution. Technetium removal technologies and/or procedures that can address this non-pertechnetate problem must be developed and/or demonstrated on actual waste.

Path to Solution

- Perform batch tests and flow studies using sorbents (i.e., anion exchange) for pertechnetate and a variety of supernate streams from Hanford to evaluate the efficiency of separation.
- Develop and test methods for separating reduced technetium (i.e., non-pertechnetate) that cannot be effectively removed using anion exchange. Methods may include oxidizing reduced technetium to the pertechnetate form, thereby allowing previously tested anionic exchange to be effective, or use of alternative materials or processes for directly separating non-pertechnetate.

FY97-99 Scope

- Perform small batch tests with sorbents, which are designed to remove pertechnetate, on a variety of supernates to determine the efficiency of separation and fraction of pertechnetate for each waste stream.
- Complete continuous flow studies with appropriate pertechnetate sorbents on the supernates with a high technetium concentration and high percentage of pertechnetate.
- Survey available technologies for removal of reduced forms of technetium (i.e., non-pertechnetate). In supernates with high technetium concentration and a low percentage of pertechnetate, alternative

technologies such as reduction, electrolytic deposition, and procedures such as oxidation of the technetium species will be explored.

- Scale chemical concepts continuous system to provide engineering data useful for design of treatment processes for both pertechnetate and non-pertechnetate forms of technetium.

Schedule

- Complete batch tests with technetium sorbents to evaluate performance for pertechnetate removal (FY97). *Engineering Development* (RL36WT41-C)
- Complete evaluation and reporting on removal processes for non-pertechnetate using real waste and novel sorbents, electrodeposition and oxidation processes identified by the Efficient Separations and Processing Crosscutting Program or AEA Technologies (FY98). *Engineering Development*
- Demonstrate technetium removal technologies at the laboratory scale, in a continuous system, with actual waste samples (FY99). *Demonstration*

Other Related Work

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA		400	1,000	700
EM-50 Crosscut Program (ESP)	1,385	700	670	
Total	1,385	1,100	1,670	700

Problem Element Title: 1.2.2.5.4 Other Radionuclides Removal from Alkaline Wastes

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	539	Hanford	Demonstration of TRU/Strontium-90 Removal
	498	ORR	Source Treatment
Secondary	N/A		

Problem Statement

In addition to the needs for removal of cesium and technetium from supernates at ORR, INEL, Hanford, and SRS, needs also exist for improvements to or alternatives to the baseline removal processes for other radionuclides, especially strontium. The primary needs identified for other radionuclides came from Hanford and ORR.

Hanford

To meet performance requirements for the LLW form at Hanford, strontium and TRU must be removed from the supernate in select tanks before immobilization. Decontamination factors of 1000 are needed for the TRUs in Tanks 104-AN and 105-AN, which contain double-shell slurry feed. Decontamination factors of 10,000 are needed for the strontium in the most of the Hanford tanks, which contain complexant concentrate waste and dilute complexant concentrate waste. The Plutonium Finishing Plant waste in Tank 102-SY requires an even higher strontium decontamination factor of 1,000,000. Four other Hanford tanks, which contain neutralized current acid waste or dilute noncomplexed waste, require strontium decontamination factors of a minimum of 1000.[a] The decontamination factors are debated by several sources Improved methods for strontium removal, especially from organic complexant-rich wastes, may be required. In addition, recent sampling of Tank 106-C sludge has identified free-phase organics. The presence of free organics may seriously impede the effectiveness of radionuclide separation processes through both fouling and possible complexation or preferential concentration of specific radionuclides. Methods for addressing problems with free-phase organics are needed.

(a) Colton, NG. 1994. *Tank waste processing analysis: database development, tank-by-tank processing requirements, and examples of pretreatment sequences and schedules as applied to Hanford double-shell tanks supernatant waste - FY 1993*. PNL-10134, Pacific Northwest Laboratory, Richland, Washington.

ORR

The High-Flux Isotope Reactor continues to operate, generating waste with significant concentrations of the intermediate half-life isotope ruthenium. Removal of ruthenium is required to allow adequate source treatment, thereby decreasing the radionuclide load on waste processing and the radiation in the waste storage tanks.

Path to Solution

- Demonstrate alternative methods for strontium removal, using a variety of available and newly developed sorbents, or a simpler solvent extraction method for alkaline waste that was developed by the Efficient Separations and Processing Crosscutting Program. Test most promising methods on Hanford tanks wastes.
- Investigate and develop processes for treatment of free-phase organics from sludges in Hanford's Tank 106-C. Results will be applicable to other Hanford tanks containing organics.
- Evaluate sorption processes to preferentially remove ruthenium from actual High-Flux Isotope Reactor wastes at ORR. Results will benefit ATR at INEL.

FY97-99 Scope

Hanford

- Complete technology screening by performing small batch tests with actual complexant concentrate and double-shell slurry feed waste from Hanford with various strontium removal processes and with waste from Tanks 104-AN and 105-An for TRU removal processes. Technology will be provided by the national laboratories, private industry, or universities.
- Complete larger scale tests on key waste types using the best strontium and TRU removal technologies identified from the batch test results.
- Conduct laboratory studies with Tank 106-C sludge samples to characterize the free-phase organics present. Studies will be conducted to determine the impact, if any, of the organics on the several baseline processing steps during treatment and solidification.
- Complete an engineering report detailing expected operating impacts and necessary process modifications that are recommended to adequately address the potential problems associated with free-phase organics.
- Complete scale up of the Sr-Talk process previously tested by the Efficient Separations and Processing Crosscutting Program, thereby allowing continuous multistage contact testing with simulated and spiked Hanford supernates.
- Demonstrate the Sr-Talk process on selected Hanford wastes and prepare engineering and cost data to users.

ORR

- Perform small-scale batch contacts in hot cells for ruthenium removal from High-Flux Isotope Reactor at ORR and/or ATR at INEL.
- Scale up the most suitable sorbents to allow continuous flow studies in Columbus.
- Provide engineering and cost data and process recommendations to ORR waste management on the most appropriate treatment options.

Schedule

Hanford

- Complete technology screening tests for strontium and TRU removal processes with tank waste from Hanford (FY98). ***Engineering Development***
- Complete bench-scale tests with the most appropriate strontium and TRU removal processes for lower concentration streams based on FY98 results (FY99). ***Engineering Development***

- Determine organic characteristics; investigate and report on impacts of free-organics on the baseline treatment processes (FY98). *Engineering Development*
- Incorporate user in demonstration of process equipment to address free-organics problems in Tank 106-C sludge washing equipment and process demonstration (see Problem Element 1.2.2.7) (FY99). *Engineering Development*
- Conduct solvent extraction countercurrent testing (Sr-Talk) with spiked surrogate wastes (FY98). *Engineering Development*
- Complete solvent extraction demonstration tests with Hanford wastes to assess the performance and cost of the Sr-Talk alternative for Sr removal (FY99). *Demonstration*

ORR

- Complete investigation of potential sorbents using batch laboratory testing (FY98). *Engineering Development*
- Conduct continuous column tests with actual High-Flux Isotope Reactor waste and recommend a treatment process with engineering and performance data to waste management (FY99). *Demonstration*

Other Related Work

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	0	0	1,750	2,050
EM-50 Crosscut Program (ESP)	2,075	1,050	980	
Total	2,075	1,050	2,730	2,050

Problem Element Title: 1.2.2.7 Process Sludge

Problem Element Description

Retrieved sludges from tank waste require processing to remove entrained radionuclides for downstream separation and processing, and to remove salts and minerals that may impact downstream vitrification. Processing of sludges primarily involves washing and separations.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	518	SRS	Develop Counter-current Decantation Process for Sludge Washing
	553	Hanford	Pretreatment Demonstration for Phase II HLW Sludges
	574	Hanford	Continuous Sludge Leaching and Processing Reactors
		INEL	
	178	ORR	Sludge Separations
Secondary	538	Hanford	Pretreatment Demonstration for Phase I Sludges

Problem Statement

Sludges at SRS, Hanford, and ORR will require processing to remove nonradioactive constituents which either adds to the volume of the resulting HLW (e.g., aluminum) for impacts immobilization processing (e.g. chromium, technetium, or phosphate). Technical problems and issues exist in three areas of sludge processing.

Performance Data on the Baseline Enhanced Sludge Washing System

The current baseline pretreatment option for Hanford tank sludges is caustic leaching followed by washing with dilute sodium hydroxide. Testing of the baseline pretreatment process with actual tank sludges is required to confirm (or amend) the assumptions made in the development of the process flowsheet. Collection of these data are essential to reducing the technical risks associated with the baseline tank waste disposal flowsheet and in fulfilling the *Hanford Federal Facility Agreement and Consent Order* target milestone M-50-03.

Sludge Washing Chemistry

Separation techniques cannot be performed on sludge leachates if material to be separated is not in solution or if the leachates contain gels or colloids. Several specific problems exists which need to be addressed.

- Several tanks at Hanford do not meet the enhanced sludge washing targets for aluminum, phosphate, chromium, and other metal oxides removal.
- Gelation and colloid formation has been observed in caustic leachates, which will impede downstream separations.

These problems point to two aspects of sludge treatment and subsequent separations that need to be well-delineated and predictable: 1) the distribution of chemical species between aqueous solutions and solids and 2) potential problems due to chemical interactions that could result in process difficulties or safety concerns.

Continuous Sludge Processing

Baseline flowsheets for SRS and Hanford are based on batch-wise sludge processing in large vessels or in-tank. Although batch processes offer some advantages, e.g. simplicity, they also present potential problems, especially when applied on a large scale. Potential drawbacks include: poor efficiency because of heterogeneity and poor mixing and less ability to control mixing, mass transfer, heat transfer, and chemical kinetics. Continuous processing on the other hand, trades some additional complexity, for significant benefits. Because the continuous process can be designed to maximize rate limiting processes, equipment sized to process an equivalent amount of waste in the same time can be processed in much smaller equipment than the corresponding batch vessels. Smaller equipment may result in reduced capital costs, less risk, better control, faster start-ups and shutdowns, and less impact and faster recovery from process upsets. However, continuous processing of sludge has not been adequately developed or tested.

Path to Solution

Baseline Enhanced Sludge Washing

- Conduct laboratory-scale testing of the baseline enhanced sludge washing flowsheets to evaluate separation efficiency.
- Perform an engineering-scale demonstration of enhanced sludge washing to confirm operating performance (i.e., baseline batch processing).

Sludge Washing Chemistry

- Evaluate methods to remove chromium, iron, and other problem metals from wastes to meet performance requirements.
- Test enhancements to sludge washing such as physical methods to increase leaching (e.g., sonification).
- Demonstrate improved sludge washing methods on Hanford and ORR waste streams.

Continuous Sludge Processing

- Test and demonstrate continuous-flow sludge processing equipment as a higher efficiency alternative to the baseline batch processes.

FY97-99 Scope

Baseline Enhanced Sludge Washing

- Conduct small-scale laboratory tests (5-20 g) on actual sludge waste from Hanford tanks to determine the effectiveness of enhanced sludge washing for separating the key, glass-limiting components of the tank sludges from the bulk of the radionuclides. This is a continuation of work performed in FY95 and FY96.
- Demonstrate at an engineering-scale, the batch processes of the Hanford baseline flowsheet. Sluiced material from Tank 106-C or another tank will be collected in FY97 for subsequent engineering-scale tests. Equipment to test enhanced sludge washing process will be built and installed. The technique will be demonstrated in cold and hot tests.

Sludge Washing Chemistry

- Evaluate methods to remove chromium from waste by oxidizing the insoluble Cr^{+3} to soluble Cr^{+6}, while retaining plutonium in the sludge.
- Conduct chemical tests on Fe removal by acetohydroxamate or oxalic acid.
- Conduct alkaline processing tests to identify materials and conditions important to the distribution of aluminum, phosphorous, chromium, silicon, and radionuclides sludge components. The influence of silica on caustic dissolution of sludge components is to be evaluated.
- Evaluate gelation and colloid formation during caustic leachate testing.
- Evaluate sonification to physically enhance sludge leaching.

Continuous Sludge Processing

- Demonstrate at the pilot scale (approx. 1/10th to full scale) continuous flow sludge pretreatment technologies from industry and other programs (e.g., Efficient Separations and Processing) which are ready for scale-up and hot demonstration.
- Design, fabricate, and operate a pilot-scale countercurrent decantation system with simulants and hot wastes to support SRS processing.

Schedule

Baseline Enhanced Sludge Washing

- Complete laboratory-scale enhanced sludge washing studies on actual tank wastes (FY98). ***Engineering Development*** (RL36WT41-A, AL16WT41-A)
- Complete design of engineering-scale test equipment based on previous years' enhanced sludge washing test results and initiate procurement for sludge washing demonstration (FY97). ***Demonstration*** (RL06WT41-A)
- Complete cold demonstration of process equipment, and initiate hot testing on Hanford sludge (FY98). ***Demonstration***
- Complete hot testing and reporting of batch enhanced sludge washing on Hanford waste (FY99). ***Demonstration***

Sludge Washing Chemistry

- Complete acid treatment, caustic dissolution, and caustic leaching tests on four Hanford sludges to evaluate alternative sludge washing chemistries and evaluate methods to control solids formation (FY97). ***Engineering Development*** (OR16WT41-B&D)
- Complete caustic leaching tests to optimize enhanced sludge washing for Hanford sludges (FY98). ***Engineering Development***
- Complete laboratory testing of chromium and critical evaluation of sonification enhancements for improved sludge washing (FY97). ***Engineering Development*** (RL36WT41-B)

- Complete scale-up of improved sludge washing and test additional chemistries for Fe removal (FY98). *Engineering Development*

<u>Continuous Sludge Processing</u>

- Design, fabricate and install pilot-scale countercurrent decant system at SRS. Initiate simulant testing (FY97). *Demonstration* (SR16WT41-B)
- Complete testing of the pilot-scale countercurrent decant circuit at SRS using sludge simulants and flocculants identified during FY96 (FY98). *Demonstration*
- Design continuous flow sludge separation system and initiate procurement for Hanford (FY98). *Demonstration*
- Install and demonstrate a continuous sludge treatment system using hot wastes at Hanford (FY99). *Demonstration*

Other Related Work

- Continuous Sludge Processing System (Industry Program FY97)
- Monitor for Sludge Washing Process (CMST FY97)

Requested Budget

Funding Source	FY96 (SK)	FY97 (SK)	FY98 (SK)	FY99 (SK)
EM-50 TFA	2,225	2,750	3,700	2,400
EM-30/40 (Multiple Sites)	2,412	250		
Total	4,637	3,000	3,700	2,400

Problem Element Title: 1.2.2.8 Prepare Pretreated Waste for Immobilization

Problem Element Description
Following pretreatment operations, supernate and sludge waste streams are transferred to HLW and LLW immobilization operations. A processing step may be required immediately following the radionuclide separation or sludge processing operations to ensure that the waste streams are acceptable for the immobilization unit operations. Processing may include additional volume reduction such as recycling, evaporation, or concentration to produce a stream more amenable to immobilization, or of reduced volume to decrease the quantity of waste requiring immobilization. The description of the multiyear plan for this portion of the tank waste processing step has been divided into sub-problem elements covering the supernate and sludge waste streams:

1.2.2.8.1 Supernate Stream to LLW Immobilization
1.2.2.8.2 Sludge HLW Stream to HLW Immobilization

Problem Element Title: 1.2.2.8.1 Supernate Stream to LLW Immobilization

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	517	SRS	Develop Electrochemical Treatment of Salt Solutions for Caustic Recovery and Recycle
	585	Hanford	Cost Effective Caustic Recycle
Secondary	N/A		

Problem Statement

Significant quantities of sodium hydroxide (caustic) will be required to store and retrieve HLW and leach sludges at the Hanford and SRS. Addition of fresh caustic for these operations will significantly increase the quantity of waste requiring disposal. HLW solutions contains large quantities of caustic that could be used for these operations if separated from other salts present in the waste thus reducing life-cycle costs.

Path to Solution

- Conduct bench-scale tests of salt splitting and membrane separation methods for caustic recycle.
- Perform long-term bench testing to determine process equipment longevity.
- Conduct a pilot-scale demonstration of caustic recycle using the preferred process(es) identified during bench-scale testing.
- Provide engineering performance and cost data to Hanford and SRS users for decisions on flowsheet revision.

FY97-99 Scope

Electrochemical salt splitting is a possible method to recover caustic from HLW solutions. During FY95, scoping tests funded by the Efficient Separations and Processing Crosscutting Program demonstrated the feasibility of electrochemical salt splitting processes for the recovery of caustic from simulants of SRS and Hanford wastes. During FY96, additional bench-scale tests were conducted to evaluate key operating parameters on the recovery of sodium hydroxide using an organic based ion-selective membrane. Factors investigated included current density, temperature and the concentrations of nitrate/nitrite, hydroxide, and aluminate. A preliminary conceptual design for caustic recovery is being initiated in FY96. The design will provide a capital and operating cost estimate for a treatment facility that will electrochemically destroy nitrate and recover caustic from the SRS decontaminated salt solution that is currently disposed in saltstone. Work was also conducted to evaluate an inorganic ceramic membrane for salt splitting funded by the Efficient Separations and Processing Crosscutting Program. In FY97-99, the TFA will

- Conduct bench-scale demonstrations of caustic recovery using radioactive liquid waste obtained from Tank 50H or the saltstone. The testing will include the use of both the organic based membrane and the ceramic stream membrane. Operating conditions will be selected based on results of simulant work completed in FY96. The caustic product from the radioactive test will be evaporated to demonstrate a method for increasing caustic concentration to meet customer requirements. Concentrations of impurities, if any, and formation of solid phases will be determined.
- Conduct a long-term bench-scale test (minimum of 1000 hours) to established membrane and other cell component durability.
- Perform pilot-scale test with testing equipment located at Savannah River Technology Center using the preferred membrane to demonstrate scale-up of the caustic recovery process.
- Provide engineering performance and cost data to SRS and Hanford waste operations with recommendations on flowsheet revisions for the preferred caustic recovery process.

Schedule

- Initiate radioactive testing at Savannah River Technology Center with SRS decontaminated salt solution (FY97). ***Engineering Development*** (SR16WT41-A)
- Conduct pilot-scale test for caustic recovery from simulated SRS waste solution and select appropriate membranes for demonstration-scale testing (FY97). ***Engineering Development*** (SR16WT41-A)
- Procure, install, and cold-test the caustic recycle demonstration unit based on specifications developed from FY97 testing (FY98). ***Demonstration***
- Complete demonstration and reporting of engineering performance and cost data on the caustic recycle process (FY99). ***Demonstration***

Other Related Work

- Electrochemical Destruction of Nitrates and Organics (ESP FY97)
- Caustic Recycle Systems (Industry Program FY97)

Requested Budget

Funding Source	FY96 (SK)	FY97 (SK)	FY98 (SK)	FY99 (SK)
EM-50 TFA	100	500	500	1,000
EM-50 Crosscut Program (ESP)	825	875	400	
Total	925	1,375	900	1,000

Problem Element Title: 1.2.2.8.2 Sludge HLW Stream to HLW Immobilization

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 599*	SRS	Concentration of Sludge Prior to Immobilization
599*	Hanford	Concentration of Sludge Prior to Immobilization
Secondary N/A		

* Need developed by TFA for program and site benefit.

Problem Statement

The current flowsheet at Hanford and SRS transports dilute and variable sludge directly to the vitrification system. The vitrification system must be over sized to handle the excessive water and heat-load requirements. Commercially available techniques are available for moisture and organic extraction, but this has not been evaluated for potential application on tank sludge.

Path to Solution

- Identify and down-select promising commercially-available sludge conditioning equipment.
- Demonstrate most promising methods on surrogate sludge wastes.
- Provide engineering performance and cost data, and recommendations to Hanford and SRS for decisions on process flowsheet revision.

FY97-99 Scope

- Compile chemical and physical properties of treated sludges and identify industrial sludge conditioning equipment potentially applicable to Hanford and SRS wastes. This task will be closely linked to the sludge treatment laboratory studies and demonstrations (Problem Element 1.2.2.7, Process Sludge).
- Conduct surrogate waste testing of sludge conditioning equipment. After evaluation and down-selection, testing on sludge conditioning will be done on surrogate waste at vendor sites. Results from this testing will be incorporated into an engineering recommendations document.

Schedule

- Compile chemical and physical properties of treated sludge system-wide and obtain sludge simulants (other TFA task) for later testing (FY98). ***Engineering Development***
- Complete evaluation and selection of vendor(s) and processes for testing (FY98). ***Demonstration***

- Complete vendor testing on surrogate wastes and provide engineering performance and cost data to users (FY99). *Demonstration*

Requested Budget

Funding Source	FY96 (SK)	FY97 (SK)	FY98 (SK)	FY99 (SK)
EM-50 TFA		0	100	400
Total		0	100	400

Problem Element Title: 1.2.3.1.1 Monitor and Control LLW Immobilization Process

Problem Element Description

The LLW stream from the pretreatment operations will require processing to produce an acceptable LLW form. Process monitoring and process control methods are critical to the production of an acceptable waste form, regardless of the specific waste form selected by the site for use.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	529	Hanford	Waste Acceptance Testing
	549	Hanford	LLW - On-Line Analysis
Secondary	492	ORR	Waste Form Acceptance

Problem Statement

Radionuclide monitoring of feed solutions to a grouting or vitrification facility and products produced from the facility is crucial to avoid exceeding product specifications for LLW, especially if the highly restrictive Class A LLW is required. In particular, a faster and cheaper method than neutron activation for technetium-99 analysis is needed for process control. On-line analysis would be needed to avoid producing TRU waste and analysis of Resource Conservation and Recovery Act metals would be needed to maintain metal concentrations below levels which would be considered a mixed waste.

Several sites in the DOE complex are interested in privatizing the immobilization function for tank wastes. For example, product acceptance monitoring is needed to support Phase I privatization at Hanford which has a goal of hot startup of a 20 metric ton/day LLW glass plant by July 2002. In general, the operator of the waste immobilization facility will return a waste form to the site, for eventual disposal. This waste form will have to meet product specifications ensuring its handling and suitability for disposal. Test methods currently defined in many cases are not suitable for radioactive materials. Many of the specified test methods were not developed for testing of glass. In most cases, there are no standards which can be used to verify the accuracy of reported results. Methods are needed to verify conformance with specifications prior to DOE taking custody of the products from the private sector.

Path to Solution

- Evaluate waste form compliance requirements that will drive monitoring and control specifications
- Evaluate adequacy of existing technology to meet specifications.
- Develop and demonstrate validated test methods, instrumentation, and standards for waste form acceptance testing.

FY97-99 Scope

- Collect and assess waste form compliance requirements to establish baseline performance specifications for monitoring.
- Identify appropriate test methods. Test methodology, supported by screening experiments, will then be proposed for each identified need. For each test method developed, a data package will be provided to interested sites which will include precision and accuracy of the test response, and assurance of the usefulness of the method for radioactive samples. (It is anticipated that this will generally be based on testing of radioactive samples.)
- Identify and procure standard materials (assumed to be at least one grout and one glass). Characterization of standard materials will include both determination of the mean response, and identification of the imprecision of the mean response, for each material for each test method.
- Develop and demonstrate test methods and on-line instrumentation for monitoring product control specifications. The instruments would monitor in real time TRUs, cesium, strontium, and technetium, and Resource Conservation and Recovery Act metals, to avoid generation of TRU or greater than Class A LLW or mixed hazardous waste. In addition, the instruments would allow for waste form product acceptance inspection. These methods will be suitable for deployment across the DOE complex, with radioactive waste forms and allow for quantitative determination of compliance with product specifications to be made. The standard materials will facilitate verification of the accuracy of reported results.
- Deploy waste form acceptance monitors for selected site use. It is anticipated that 3-5 years of development and/or modification of commercial instrumentation will be required to develop an array of instruments to monitor all of the required product specifications from the sites. The application initially would be to support Phase I privatization at Hanford, but could have application to all other tank sites.

Schedule

- Identify compliance data needs (FY97). ***Engineering Development*** (RL06WT31-B)
- Complete identification and evaluation of standard materials, available methods, and the precision and accuracy of existing methods and instrumentation (FY97). ***Engineering Development*** (RL06WT31-B)
- Demonstrate and evaluate available methods for waste acceptance monitoring, and identify improvements required for full implementation (FY98). ***Demonstration***
- Complete improvements to methods and instrumentation, validate performance, and implement for selected site use (FY99). ***Implementation***

Other Related Work

- Waste Forms Initiative (MWFA FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA		500	1600	1600
EM-30/40 (Multiple Sites)	1,318	250	250	
Total	1,318	750	1,850	1600

Problem Element Title: 1.2.3.1.3 Immobilize LLW Stream

Problem Element Description

The LLW streams produced during pretreatment separation operations at each of the tank waste sites will require immobilization to produce an acceptable waste form for disposal. Each of the DOE tank waste sites are considering different immobilization and disposal options for LLW, ranging from grout to glass, and from on-site disposal to off-site transport.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	524	SRS	Evaluate LLW Vitrification as an Alternative to Saltstone
	252	INEL	Develop Grout Process for Sodium Bearing Waste
	189	ORR	Secondary Waste Immobilization Studies
	493	ORR	Sludge Waste Form Study
	494	ORR	Sludge Waste Form Demonstration
Secondary	529	Hanford	Waste Acceptance Testing
	492	ORR	Waste Form Acceptance

Problem Statement

Disposal of low activity tank wastes is being approached very differently at individual DOE sites, and, in some cases, even within a single site. Specific technical issues and needs exist at the sites for selection of the most appropriate and acceptable waste forms.

The current strategy for immobilization and disposal of ORR tank wastes is based on privatization. Expressions of interest and comments on a draft Request for Proposal for treatment of the Melton Valley Storage Tank waste have been solicited from the private sector. The strategy is predicated on the ability of private vendors to reliably immobilize the waste into forms suitable for disposal at either the Nevada Test Site or the Waste Isolation Pilot Plant. It is anticipated that vendors are most likely to propose either grout or glass forms. Before the awarding of a contract with a private vendor, ORR will put additional wastes into the Melton Valley Storage Tank, changing the average tank waste composition. In addition, Oak Ridge National Laboratory has some ability to blend the waste, if desired. The impacts of these changes in composition on waste processing, waste form acceptability, waste form volume, and waste disposal costs have not yet been determined. Once the impacts are known, they can provide crucial input to waste tank operators making decisions about waste movement and blending. They can also provide a frame of reference to ORR for use in judging the adequacy of private sector responses to the request for proposal.

At INEL, the programmatic SNF and INEL Environmental Restoration and Waste Management Environmental Impact Statement record of decision selected radionuclide partitioning as the preferred method of treatment for radioactive liquid and calcine waste stored at the Idaho Chemical Processing Plant. A Settlement Agreement and Consent Order between the state of Idaho, DOE, and the Navy requires DOE to negotiate a plan and schedule for waste treatment by December 31, 1999, such that all waste can be immobilized and ready for shipment to a Federal repository by 2035. Technology for immobilization of the low-activity waste fraction must be identified and evaluated so that a plan and schedule for the waste treatment facility can be negotiated. This same information is also needed to support facility design.

In addition to these needs for immobilization technology development and evaluation, Hanford and ORR also require waste acceptance criteria and testing methods for the selected LLW form. Problem Element 1.2.3.1.1. describes these related monitoring and control needs and their respective paths to solution.

Path to Solution

- Develop specifications/functional requirements for grout waste formulations for INEL and grout and glass waste forms for ORR.
- Test and evaluate grout formations for INEL's high aluminum, zirconium, and sodium wastes.
- Develop, test, and evaluate grout and glass waste forms for ORR.
- Provide engineering performance and cost data which can be used across the DOE system to judge the suitability of glass and grout as the waste forms for the LLW fraction contained in the tanks at ORR, Hanford, and INEL.

FY97-99 Scope

Work activities within the TFA are intended to provide processing data and product data (short-term acceptance testing and long-term performance testing) to allow the tank sites to reach well-thought out decisions on waste forms for these types of waste.

Specific work activities will

- Define the range of waste compositions representing the variety of ORR waste types and blends likely to be encountered.
- Develop and test acceptable grout and glass formulations using simulated wastes.
- Develop and test grout formulations for the immobilization of INEL's low-activity waste. In conjunction with Environmental Management programs funded by INEL, testing will be conducted to meet key objectives of maximizing waste loading, volume reduction, and process reliability.
- Conduct radioactive waste tests with the grout and glass formulation(s) to produce performance data needed for ORR processing decisions.
- Obtain engineering performance data for INEL's low-activity waste immobilization. Results will include performance on preconditioning processes, mixing requirements, and grout curing and fluid properties. Product data, including compressive strength, leach resistance, thermal cycling, and immersion test results will also be developed.
- Solicit regulatory involvement early in the process so that disposal of the resulting waste forms can be accomplished.

Schedule

ORR LLW

- Complete development of specifications/functional requirements for grout and glass forms for ORR (FY97). *Engineering Development* (OR17WT31-A, SR16WT31-A)
- Complete initial testing of radioactive grout and glass waste forms (FY97). *Engineering Development* (OR17WT31-A, SR16WT31-A)
- Complete characterization and evaluation of the grout and glass waste form products (FY98). *Engineering Development*

INEL Calcine Waste

- Complete testing and evaluation of grout formulations for INEL's low-activity waste grout from high aluminum and high zirconium calcine with actual waste (FY98). *Demonstration*
- Complete testing and evaluation of grout formulations for INEL's low-activity waste grout from high sodium calcine with actual waste (FY99). *Demonstration*

Other Related Work

- Performance Assessment for Waste Grouting of LLW for ORR (International Programs FY97)
- Grouting of LLW for ORR (International Programs FY97)
- Immobilization of Fission Products in Phosphate Ceramics (ESP FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	900	1,300	1,350	1,350
EM-30/40 ORR	250	1,000	1,125	
EM-30/40 Hanford	580			
EM-30/40 INEL	160	371		
EM-30/40 SRS	270			
Total	2,160	2,671	2,475	1,350

Problem Element Title: 1.2.3.2.1 Monitor and Control HLW Immobilization Process

Problem Element Description

The HLW stream from the pretreatment operations will require processing to produce an acceptable HLW form. Process monitoring and process control methods are critical to the production of an acceptable waste form. Process monitoring and control may include on-line sensors for measurement of feed stream concentrations, as well as analysis methods for monitoring the waste form product exiting the immobilization process equipment.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	285	SRS	Improve Defense Waste Processing Facility Analytical Methods and Facilities
	529	Hanford	Waste Acceptance Testing
Secondary	N/A		

Problem Statement

Radionuclide monitoring of feed solutions to a vitrification facility and products produced from the facility is crucial to avoid producing out of specification waste forms for HLW. HLW product specification criteria place upper limits on chemical species considered detrimental to good glass formulations. In particular, the weight percent of sulfates, chromates, phosphates, nickel, chlorides and mercury are limited.

Under phase I privatization at Hanford, DOE has the option to begin hot startup of a HLW vitrification plant (one metric ton/day) by July 2002 and hot-startup of a full-scale plant in 2013 (via phase II privatization). After the immobilized waste form is produced, methods for acceptance inspection and testing of the waste form are needed to verify conformance with specifications prior to DOE taking custody of the products from the private sector. Product characteristics that may be measured include internal cracking, secondary phase formation, void volume, chemical and radiochemical composition, homogeneity, and container integrity.

Path to Solution

- Identify performance specifications for on-line instrumentation.
- Develop instrumentation for process feed and produced waste form analysis.
- Demonstrate on-line instrumentation in support of Hanford's phase I privatization, and to augment processing at SRS's Defense Waste Processing Facility. Three to five years of development and testing or modification of commercial instrumentation is likely to be required to develop the array of instruments to monitor all of the required product specifications/parameters. Activities would initially support Phase I and Phase II privatization at Hanford, but could have application to the other tank sites.

FY97-99 Scope

- Identify performance specifications and limitations of available technology for on-line monitoring of immobilization process feed and waste product.
- Develop and demonstrate on-line instrumentation for monitoring product control specifications for the immobilization process feed streams. The instruments would monitor in real time glass, limiting species such as sulfates, chromates, phosphates, nickel, chlorides, and mercury.
- Develop and demonstrate instrumentation for product acceptance inspection after the waste form was produced and include other parameters such as internal cracking, secondary phase formation, void volume, chemical and radiochemical composition, homogeneity, and container integrity.

Schedule

- Complete survey of an available instrumentation and assessment of user performance specifications (FY98). ***Engineering Development***
- Initiate engineering development to adapt or develop on-line process monitors to meet user requirements (FY98). ***Engineering Development***
- Demonstrate on-line instrumentation for immobilization process monitoring, and evaluate performance relative to user requirements (FY99). ***Demonstration***

Other Related Work

- NH_4 Monitor (CMST FY97)
- Effective Surface of Glass Waste Forms (FIU FY97)
- Defense Waste Processing Facility Analytical Testing (SRS/EM-30 FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA		0	600	600
Total		0	600	600

Problem Element Title: 1.2.3.2.2 Prepare Secondary Waste from Pretreatment

Problem Element Description

Pretreatment operations will generate secondary solid and liquid wastes which may require additional processing to obtain acceptable final waste forms. For example, large quantities of spent ion exchange resin will be produced during the radionuclide separation operations within pretreatment. Subsequent processing and immobilization of these secondary wastes may be required.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 489	ORR	Liquid LLW Supernatant
Secondary 567	Hanford	Crystalline Silicotitanate in HLW Glass

Problem Statement

One of the promising new separations technologies being demonstrated within the TFA is removal of cesium from the soluble fraction of the HLW using crystalline silicotitanate. This ion exchange resin is currently being used as part of Melton Valley Storage Tank cesium removal demonstration at ORR. In addition, crystalline silicotitanate use is being evaluated and/or considered for Hanford and SRS. As with all ion exchange resins, crystalline silicotitanate resin disposal may require subsequent processing. Specifically, ORR requires engineering performance and cost data on ion exchange resin vitrification to support a decision on secondary waste crystalline silicotitanate resin disposal.

A key technical issue with crystalline silicotitanate resin vitrification is the ability to incorporate significant waste quantity into the glass waste form. This issue is not unique to ion exchange resins or other secondary wastes. The amount of waste which can be incorporated into any glass is affected by both the major and minor components in the waste. If a minor component has limited solubility in the waste glass, then it may determine the amount of glass which must be produced. Titanium is a primary component of Crystalline silicotitanate resins and has been shown to limit the amount of waste which can be incorporated into glass. The solubility of components in glass, such as titanium, chromium, iron, aluminum, silicon, etc., are being addressed as part of other minor component solubility work activities in problem element 1.2.3.2.4, and are not discussed here.

Path to Solution

- Demonstrate immobilization of spent ion-exchange resins from a cesium separation process.

- Provide engineering and cost performance data to users to support implementation of secondary waste vitrification.

FY97-99 Scope

- Load crystalline silicotitanate resin with cesium as part of the Melton Valley Storage Tank Demonstration.
- Transport loaded resin from ORR to the Savannah River Technology Center's Shielded Cells for immobilization testing.
- Demonstrate two immobilization processes: a sludge-crystalline silicotitanate glass process and a crystalline silicotitanate-only glass process.
- Characterize important process parameters during immobilization (e.g., slurry rheology, offgas generation).
- Provide engineering performance to ORR and other sites on the ability of each glass product to satisfy DOE Environmental Management's vitreous materials specifications.
- Dispose of the waste glass product to the Nevada Test Site.

Schedule

- Initiate vitrification of crystalline silicotitanate resins from the ORR Melton Valley Storage Tank cesium separation demonstration (FY97). ***Demonstration***
- Complete crystalline silicotitanate resin vitrification demonstration and provide engineering performance and cost data to Environmental Management users. Document results of demonstration (characterizing process behavior and product performance) and compatibility of crystalline silicotitanate with various flowsheets (FY98). ***Demonstration***

Other Related Work

- Cement Solidification of Spent Ion-Exchange Materials (International Programs/AEA Technologies FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	755	2,000	200	
Total	755	2,000	200	

Problem Element Title: 1.2.3.2.3 Prepare Sludge Feed

Problem Element Description

Following pretreatment, high-activity waste supernate and sludge is stored awaiting transfer to the HLW immobilization process. The waste requires preparation such as blending, mixing, or composition adjustment prior to transfer to the immobilization process. This problem element encompasses the necessary processing required to prepare the post-pretreatment high-activity wastes for immobilization.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 66	SRS	Prepare Melter Feed - Enhance Pumping/Mixing
Secondary N/A		

Problem Statement

Issues with mobilization and transfer of waste sludge to the HLW melters were raised as the primary problem affecting SRS within this problem element. Sludge mobilization and transfer are directly impacted by the selection of sludge feed processing operations.

In vitrification facilities such as the Defense Waste Processing Facility at SRS, the process is controlled through control of the feed composition. If melter feed is not well-mixed, it will affect process and equipment reliability, and in extreme cases may jeopardize the life of the melter. Analysis of feed samples which are not representative of the feed, may have the same consequences. While Defense Waste Processing Facility agitation and sampling systems were found to be adequate, this was based on necessarily short-term testing. In addition, these systems were designed in the early 1980's. Significant improvements in the understanding of slurry rheology, and in the design of agitation and sampling systems has occurred since then. The performance of the sludge feed system needs to be enhanced through coupling of the improved understanding and equipment designs with the experience from initial Defense Waste Processing Facility.

Path to Solution

- Establish requirements for mixing and handling waste sludges.
- Procure and evaluate commercial system that meet functional requirements.

FY97-99 Scope

- Develop functional requirements for agitation and sampling systems. The results of initial Defense Waste Processing Facility operating experience and of slurry rheology determinations being carried out by each of the sites and by Florida International University will be used.
- Demonstrate commercial systems and evaluate performance relative to the functional requirements. The requirements for agitation and sampling will be provided to commercial vendors who will then be given the opportunity to demonstrate the effectiveness of their equipment to satisfy these specifications, using representative Defense Waste Processing Facility or Hanford simulants.

Schedule

- Complete preparation of functional requirements for vendors (FY98). ***Engineering Development***
- Initiate demonstration of vendor systems on sludge feed simulants (FY98). ***Demonstration***
- Complete demonstration of vendor system and prepare engineering performance and cost data to support user decisions (FY99). ***Demonstration***

Other Related Work

- Comparison of Enhanced Mixing Technology (FIU and Industry Program FY98)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA			400	200
EM-50 Industry/University Programs			2,250	
EM-30/40 SRS	447			
EM-30/40 Hanford	1,400	760	50	
Total	1,847	760	2,700	200

Problem Element Title: 1.2.3.2.4 Immobilize HLW Stream

Problem Element Description

Immobilization of the HLW streams at INEL, SRS, and Hanford are required to produce an acceptable HLW form for final disposal. Calcine immobilization and vitrification are the baseline methods for HLW immobilization. This problem element addresses the calcination and vitrification processing needs of these sites.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 558	Hanford	Process for Immobilization of Technetium-Rich Waste Stream
561	Hanford	Radioactive Small-Scale Vitrification Demonstration
1	INEL	Develop HLW Formulations for the High Activity Fraction of Sodium-Bearing Waste and Calcine
5	INEL	Integrated Demonstration of Immobilization Equipment
189	ORR	Secondary Waste Immobilization Studies
520	SRS	Optimize Waste Loading for Defense Waste Processing Facility Glass
Secondary 542	Hanford	Radioactive HLW Vitrification Tests - Phase I
554	Hanford	Waste Loading Optimization for HLW
315	SRS	Extend Operating Life of Defense Waste Processing Facility Melter

Problem Statement

The primary needs in immobilization of high-activity wastes were received from Hanford, INEL, and SRS. At Hanford and SRS extending the operating life of HLW vitrification systems and optimizing the solubility of components in the waste glass will be important issues. In addition, selection of the most appropriate immobilization system at Hanford and INEL will be critical issues in the next few years. The specific problems identified in the HLW immobilization problem element include

Advanced Materials for Vitrification at Hanford and SRS
As part of the development supporting design of HLW immobilization facilities at Hanford and SRS, and testing in support or startup of the Defense Waste Processing Facility, corrosion of materials in specific environments has been observed. In particular, severe corrosion of Inconel 690 in high halide or high sulfate environments has been observed.

The work supporting the selection of materials for immobilization processes, particularly melters, is nearly 20 years old. New materials have been developed which should have better service life in specific environments. Identification of materials which will extend the operating life of process equipment, particularly in the melter and offgas system (the areas of highest concern) is needed.

Vitrification of INEL High-Activity Waste
A Settlement Agreement and Consent Order between the state of Idaho, DOE, and the Navy requires DOE to negotiate a plan, and schedule for waste treatment by December 31, 1999, such that all waste can be immobilized and ready for shipment to a federal repository by 2035. Technology for immobilization of the high-activity waste fraction must be identified and evaluated so that a plan and schedule for the waste treatment facility can be negotiated. This same information is also needed to support facility design.

Advanced Immobilization Systems for Hanford
Hanford has not yet selected the technology to deploy for the high-activity fraction of the tank wastes. EM-50 has sponsored development of alternative technologies which may offer longer service life, lower costs, or otherwise more robust designs. Testing of these alternative processes with representative waste simulants is needed to produce engineering performance and cost data to support final technology selection.

High-activity wastes derived from tank farm liquid wastes and calcined wastes at the Idaho Chemical Processing Plant are to be immobilized in glass. The projected high-activity waste potentially contains halides and other species which are corrosive to melter materials of construction (refractories and metals). Earlier waste simulants caused severe corrosion in melting tests. Current glass formulation tools do not include algorithms addressing melter materials corrosion. Materials of construction have not been identified for the current waste composition projections. The relationships between melt process variables and corrosion rates are not known for these compositions, nor have optimal materials of construction been identified.

Optimization of Glass Component Solubility
The amount of glass which must be produced by a vitrification facility is determined by the amount of waste which can be incorporated in the glass. The amount of glass which must be produced affects the size and subsequent cost of the facility, and the schedule for final remediation of the waste tanks. The amount of waste which can be incorporated in the glass is affected by both the major and minor components in the waste. For SRS tank wastes and much of the Hanford tank waste, the major waste components (e.g., iron, aluminum, alkali cations, silicon) will determine the waste loading by affecting important process and product parameters. For example, the amount of Hanford low-activity waste which can be incorporated in borosilicate glass is limited by the affect of sodium in the waste on the durability of the glass product. Aluminum limits waste loading through its affect on melt viscosity. Iron limits waste loading through its effect on the glass liquids temperature. Methods are needed to increase the levels of these components which can be included in waste glasses.

Path to Solution

- Identify life-limiting conditions for melter materials, and test promising advanced materials. Test and evaluate commercial advanced immobilization processes using waste simulants
- Identify methods to optimize key component solubility in waste glass to support both secondary waste and improved HLW vitrification

FY97-99 Scope

Advanced Materials

- Define and evaluate the conditions which are life-limiting for the vitrification and offgas process equipment.
- Identify promising candidate materials for specific service conditions. A workshop will be held with materials vendors to support this effort.
- Evaluate the performance (i.e., corrosion, degradation, etc.) of selected material samples introduced into test melters.
- Disseminate materials testing results to both the vendors and to the site users, so that equipment life can be extended through incorporation of new materials into the design and change-out of melters.

Vitrification of INEL High-Activity Waste

Testing will be performed on simulated waste, and verified through selective testing with actual wastes to develop appropriate glass formulations, melter construction materials, and to develop and demonstrate a calcine immobilization process.

Melter Materials

- Test candidate materials under varying simulated waste glass melts
- Develop a quantitative relationship between process variables and material corrosion rates

Glass Formulations

- Conduct bench-scale experiments to establish near-field and far-field durability of glass formulations
- Determine product characteristics and process capability.
- Qualify the waste form.

Calcine Immobilization Process

- Define the type of glass melter and offgas treatment process required, based on glass formulation and melter materials activities (above).
- Conduct integrated nonradioactive testing on a laboratory scale to verify the selected system.

Advanced Immobilization

- Procure representative waste simulants and establish contracts with commercial vendors to perform advanced melter testing.
- Evaluate melter systems based on throughput, effluents, and product quality and process reliability. Tank user personnel will be invited to participate in test planning, test monitoring, and evaluation of results.
- Provide engineering performance and cost data to site users with recommendations on the advanced melters with most promise for specific waste streams.

Optimization of Glass Component Solubility

- Develop methods to maximize the content of minor components in glass. This task will focus on species contained in SRS, ORR, and Hanford wastes or which will be constituents of products from pretreatment processes (e.g., titanium from a crystalline silicotitanate ion-exchange process). Initial bench-scale studies will be focused on iron, aluminum, silicon, zirconium, and alkali cations, Additional studies will be performed on chromium, phosphate, halides, technetium, the actinides, and species in crystalline silicotitanate resins. These studies may include modification of the glass chemical composition, modification of the chemical form of the species during melter feed preparation, or varying glass melter operating parameters.

- Test promising methods for maximizing component solubility in small continuous melters with representative waste simulants to establish their efficacy in increasing waste loading during actual facility operations. These may include temperature, modification of the chemical form, or varying the redox state of the glass melt.
- Provide engineering performance and cost data and recommendations on enhancements for optimizing component solubility to the Hanford and SRS users.

Schedule

Advanced Materials

- Identify life-limiting service conditions, and candidate materials for testing. Initiate candidate material sample testing (FY98). ***Engineering Development***
- Complete evaluation of test materials and prepare engineering performance data to site users (FY99). ***Engineering Development***

Vitrification of INEL High-Activity Waste

- Complete corrosion tests with simulated INEL high-activity waste (FY97). ***Engineering Development*** (RL06WT31-E)
- Complete development of relationships between processing variables and melter materials corrosion rates (FY97). ***Engineering Development*** RL06WT31-E)
- Establish glass compositions for HAW fraction, based on pretreatment processes (FY98). ***Engineering Development***
- Complete testing of high-activity waste forms containing actual INEL waste (FY99). ***Engineering Development***
- Complete laboratory-scale melter tests with simulated calcine waste (FY98) ***Engineering Development***
- Provide specifications for materials of construction for the calcine immobilization facility to site users (FY99). ***Engineering Development***
- Decision point for initiation of testing with actual INEL waste (FY99). ***Engineering Development***

Advanced Immobilization

- Identify advanced immobilization technologies to be tested (FY98). ***Engineering Development***
- Procure simulants and vendor services for initiation of advanced immobilization testing (FY98). ***Engineering Development***
- Complete testing of selected commercial immobilization systems using waste simulants (FY99). ***Demonstration***
- Prepare engineering performance and cost data from testing results and submit to site users for support of process selection (FY99). ***Demonstration***

Optimization of Glass Component Solubility

- Complete survey of waste component solubilities and critical experiments to resolve differences in existing models (FY97). ***Engineering Development*** (RL06WT31-A)
- Recommend testing to demonstrate effectiveness of methods to increase solubility (FY97). ***Engineering Development*** (RL06WT31-A)

- Test methods for maximizing solubility of minor components such as chromium and titanium in glass (FY98). *Engineering Development*
- Develop and pilot test methods for maximizing the glass waste loading of components evaluated in FY97 (FY98). *Demonstration*
- Incorporate waste loading optimization results in process control model for Defense Waste Processing Facility, and in the Hanford flowsheet (FY99). *Implementation*

Other Related Work
- Optimization of Waste Loading in Glass (SRS/EM-30 FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	500	450	2,900	2,500
EM-30/40 SRS	78			
EM-30/40 INEL	400	535		
EM-30/40 Hanford	980			
Total	1,958	935	2,900	2,500

Problem Element Title: 1.2.3.2.5 Treat HLW Offgas

Problem Element Description

During tank waste immobilization processing, a secondary offgas waste stream is produced. The immobilization process selected, the waste being treated, and the specific operating conditions of the process all impact the volume and composition of the offgas stream produced.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 282	SRS	Cold Cap/Offgas Thermodynamics Model
Secondary 543	Hanford	LLW - Offgas Treatment

Problem Statement

The objective of waste vitrification is to immobilize a wide range of hazardous species in a glass matrix. Because the waste composition is variable, the composition of the glassy phase, and of species volatilized from the molten glass will also vary, over at least as wide a range. Effective control of vitrification processes, and a reliable design of process equipment, require an understanding of the interactions between feed composition and melter conditions. An understanding of these interactions is also essential for preventing or remediating corrosion problems in melter vapor space and offgas systems, and for optimizing waste loading in glass.

Path to Solution

- Develop a tool which can be used by process designers to predict offgas compositions, and the ultimate fate of various species (e.g., technetium) in HLW when fed to a melter.
- Integrate the model into commercial simulation packages for use by the sites in designing and optimizing vitrification process equipment selection and operations.

FY97-99 Scope

- Identify test data requirements for model development.
- Adapt existing models to predict the amount and composition of glass and offgas from a given feed composition and melter operating condition.
- Validate the model with test data from appropriate melting tests. Experiments will utilize simulants and conditions provided by Hanford users and directly applicable to Hanford LLW. Validation will occur with results independent of any data used to develop the model.

- Integrate the model with commercial process simulation packages. It is anticipated that the model will be developed so that it is compatible with one or more commercial process simulation codes. It is highly desirable that the model either be embedded in such a code, or that the model be available in source code form so that it can be readily embedded in a commercial package.

Schedule

- Complete documented model of cold cap/offgas chemistry (FY97). ***Engineering Development*** (RL06WT31-C)
- Validate model with independent vitrification process data (FY98). ***Demonstration***
- Provide model to users in a form compatible with commercial process simulation software (FY98). ***Implementation***

Other Related Work

- Cold Cap/Thermodynamics Model (SRS/EM-30 FY97)
- Mercury Treatment in Offgas Streams (MWFA FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	0	150	150	0
EM-30/40 Hanford	250			
Total	250	150	150	0

Problem Element Title: 1.3.1.3 Define Closure Criteria

Problem Element Description

Closure of radioactive waste tanks requires close interface with the retrieval operations to ensure that residual waste volume and constituents meets closure requirements. This problem element addresses the process step where the requirements for closure are adequately defined relative to the regulatory, technical, stakeholder, and cost drivers.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 528	Hanford	Tank Closure Demonstration for an Arid Site
437	SRS	Tank Clean and Closure
455	ORR	Establish Clean-up Standard/Criteria
Secondary 165	INEL	Determination of a Generalized Risk-Based Closure Criteria
435	SRS	Determine Zeolite Removal Requirements
454	SRS	Stabilization and Closure Analysis Tools
459	SRS	Data for Closure

Problem Statement

Hanford, SRS, and ORR are pursuing closure or preparations for closure of waste tanks during the FY96-99 time frame. A key issue is the definition of closure criteria and defining "how clean is clean?" Determining how much waste can be left in the tanks and meet the appropriate regulatory requirements which protect human health and the environment is of primary importance.

At SRS, tank closure activities in the near-term are focused specifically on Tank 19 and the four-tank configuration of Tanks 17, 18, 19, 20 in the F Area tank farm. An evaluation of the variety of alternative closure options (in addition to grout over the waste) needs to be performed and source term conceptual models need to be developed.

At Hanford, tank closure activities in the near term are focused specifically on the Hanford Tanks Initiative with Tanks 104-AX and 106-C. Performance and cost-based closure criteria for Hanford's

Path to Solution

- Identify life-limiting conditions for melter materials, and test promising advanced materials. Test and evaluate commercial advanced immobilization processes using waste simulants
- Identify methods to optimize key component solubility in waste glass to support both secondary waste and improved HLW vitrification

FY97-99 Scope

Advanced Materials

- Define and evaluate the conditions which are life-limiting for the vitrification and offgas process equipment.
- Identify promising candidate materials for specific service conditions. A workshop will be held with materials vendors to support this effort.
- Evaluate the performance (i.e., corrosion, degradation, etc.) of selected material samples introduced into test melters.
- Disseminate materials testing results to both the vendors and to the site users, so that equipment life can be extended through incorporation of new materials into the design and change-out of melters.

Vitrification of INEL High-Activity Waste

Testing will be performed on simulated waste, and verified through selective testing with actual wastes to develop appropriate glass formulations, melter construction materials, and to develop and demonstrate a calcine immobilization process.

Melter Materials

- Test candidate materials under varying simulated waste glass melts
- Develop a quantitative relationship between process variables and material corrosion rates

Glass Formulations

- Conduct bench-scale experiments to establish near-field and far-field durability of glass formulations
- Determine product characteristics and process capability.
- Qualify the waste form.

Calcine Immobilization Process

- Define the type of glass melter and offgas treatment process required, based on glass formulation and melter materials activities (above).
- Conduct integrated nonradioactive testing on a laboratory scale to verify the selected system.

Advanced Immobilization

- Procure representative waste simulants and establish contracts with commercial vendors to perform advanced melter testing.
- Evaluate melter systems based on throughput, effluents, and product quality and process reliability. Tank user personnel will be invited to participate in test planning, test monitoring, and evaluation of results.
- Provide engineering performance and cost data to site users with recommendations on the advanced melters with most promise for specific waste streams.

Optimization of Glass Component Solubility

- Develop methods to maximize the content of minor components in glass. This task will focus on species contained in SRS, ORR, and Hanford wastes or which will be constituents of products from pretreatment processes (e.g., titanium from a crystalline silicotitanate ion-exchange process). Initial bench-scale studies will be focused on iron, aluminum, silicon, zirconium, and alkali cations, Additional studies will be performed on chromium, phosphate, halides, technetium, the actinides, and species in crystalline silicotitanate resins. These studies may include modification of the glass chemical composition, modification of the chemical form of the species during melter feed preparation, or varying glass melter operating parameters.
- Test promising methods for maximizing component solubility in small continuous melters with representative waste simulants to establish their efficacy in increasing waste loading during actual facility operations. These may include temperature, modification of the chemical form, or varying the redox state of the glass melt.
- Provide engineering performance and cost data and recommendations on enhancements for optimizing component solubility to the Hanford and SRS users.

Schedule

Advanced Materials

- Identify life-limiting service conditions, and candidate materials for testing. Initiate candidate material sample testing (FY98). ***Engineering Development***
- Complete evaluation of test materials and prepare engineering performance data to site users (FY99). ***Engineering Development***

Vitrification of INEL High-Activity Waste

- Complete corrosion tests with simulated INEL high-activity waste (FY97). ***Engineering Development*** (RL06WT31-E)
- Complete development of relationships between processing variables and melter materials corrosion rates (FY97). ***Engineering Development*** RL06WT31-E)
- Establish glass compositions for HAW fraction, based on pretreatment processes (FY98). ***Engineering Development***
- Complete testing of high-activity waste forms containing actual INEL waste (FY99). ***Engineering Development***
- Complete laboratory-scale melter tests with simulated calcine waste (FY98) ***Engineering Development***
- Provide specifications for materials of construction for the calcine immobilization facility to site users (FY99). ***Engineering Development***
- Decision point for initiation of testing with actual INEL waste (FY99). ***Engineering Development***

Advanced Immobilization

- Identify advanced immobilization technologies to be tested (FY98). ***Engineering Development***
- Procure simulants and vendor services for initiation of advanced immobilization testing (FY98). ***Engineering Development***
- Complete testing of selected commercial immobilization systems using waste simulants (FY99). ***Demonstration***
- Prepare engineering performance and cost data from testing results and submit to site users for support of process selection (FY99). ***Demonstration***

Optimization of Glass Component Solubility

- Complete survey of waste component solubilities and critical experiments to resolve differences in existing models (FY97). ***Engineering Development*** (RL06WT31-A)
- Recommend testing to demonstrate effectiveness of methods to increase solubility (FY97). ***Engineering Development*** (RL06WT31-A)
- Test methods for maximizing solubility of minor components such as chromium and titanium in glass (FY98). ***Engineering Development***
- Develop and pilot test methods for maximizing the glass waste loading of components evaluated in FY97 (FY98). ***Demonstration***
- Incorporate waste loading optimization results in process control model for Defense Waste Processing Facility, and in the Hanford flowsheet (FY99). ***Implementation***

Other Related Work

- Optimization of Waste Loading in Glass (SRS/EM-30 FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	500	450	2,900	2,500
EM-30/40 SRS	78			
EM-30/40 INEL	400	535		
EM-30/40 Hanford	980			
Total	1,958	935	2,900	2,500

Problem Element Title: 1.2.3.2.5 Treat HLW Offgas

Problem Element Description
During tank waste immobilization processing, a secondary offgas waste stream is produced. The immobilization process selected, the waste being treated, and the specific operating conditions of the process all impact the volume and composition of the offgas stream produced.

Priority Site Needs
The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 282	SRS	Cold Cap/Offgas Thermodynamics Model
Secondary 543	Hanford	LLW - Offgas Treatment

Problem Statement
The objective of waste vitrification is to immobilize a wide range of hazardous species in a glass matrix. Because the waste composition is variable, the composition of the glassy phase, and of species volatilized from the molten glass will also vary, over at least as wide a range. Effective control of vitrification processes, and a reliable design of process equipment, require an understanding of the interactions between feed composition and melter conditions. An understanding of these interactions is also essential for preventing or remediating corrosion problems in melter vapor space and offgas systems, and for optimizing waste loading in glass.

Path to Solution
- Develop a tool which can be used by process designers to predict offgas compositions, and the ultimate fate of various species (e.g., technetium) in HLW when fed to a melter.
- Integrate the model into commercial simulation packages for use by the sites in designing and optimizing vitrification process equipment selection and operations.

FY97-99 Scope
- Identify test data requirements for model development.
- Adapt existing models to predict the amount and composition of glass and offgas from a given feed composition and melter operating condition.

- Validate the model with test data from appropriate melting tests. Experiments will utilize simulants and conditions provided by Hanford users and directly applicable to Hanford LLW. Validation will occur with results independent of any data used to develop the model.
- Integrate the model with commercial process simulation packages. It is anticipated that the model will be developed so that it is compatible with one or more commercial process simulation codes. It is highly desirable that the model either be embedded in such a code, or that the model be available in source code form so that it can be readily embedded in a commercial package.

Schedule

- Complete documented model of cold cap/offgas chemistry (FY97). ***Engineering Development*** (RL06WT31-C)
- Validate model with independent vitrification process data (FY98). ***Demonstration***
- Provide model to users in a form compatible with commercial process simulation software (FY98). ***Implementation***

Other Related Work

- Cold Cap/Thermodynamics Model (SRS/EM-30 FY97)
- Mercury Treatment in Offgas Streams (MWFA FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	0	150	150	0
EM-30/40 Hanford	250			
Total	250	150	150	0

Problem Element Title: 1.3.1.3 Define Closure Criteria

Problem Element Description

Closure of radioactive waste tanks requires close interface with the retrieval operations to ensure that residual waste volume and constituents meets closure requirements. This problem element addresses the process step where the requirements for closure are adequately defined relative to the regulatory, technical, stakeholder, and cost drivers.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.		Site	Need Title/Description
Primary	528	Hanford	Tank Closure Demonstration for an Arid Site
	437	SRS	Tank Clean and Closure
	455	ORR	Establish Clean-up Standard/Criteria
Secondary	165	INEL	Determination of a Generalized Risk-Based Closure Criteria
	435	SRS	Determine Zeolite Removal Requirements
	454	SRS	Stabilization and Closure Analysis Tools
	459	SRS	Data for Closure

Problem Statement

Hanford, SRS, and ORR are pursuing closure or preparations for closure of waste tanks during the FY96-99 time frame. A key issue is the definition of closure criteria and defining "how clean is clean?" Determining how much waste can be left in the tanks and meet the appropriate regulatory requirements which protect human health and the environment is of primary importance.

At SRS, tank closure activities in the near-term are focused specifically on Tank 19 and the four-tank configuration of Tanks 17, 18, 19, 20 in the F Area tank farm. An evaluation of the variety of alternative closure options (in addition to grout over the waste) needs to be performed and source term conceptual models need to be developed.

At Hanford, tank closure activities in the near term are focused specifically on the Hanford Tanks Initiative with Tanks 104-AX and 106-C. Performance and cost-based closure criteria for Hanford's Tanks 104-AX and 106-C are needed that are acceptable to DOE, its regulators, and interested stakeholders.

At ORR, there is a need, as part of the Gunite and Associated Tanks-Treatability Study, to plan, design, execute and operate a closure demonstration on one of the gunite tanks. This demonstration would validate strategies, closure criteria, performance, and costs that are associated with this activity to allow for planning the eventual closure of all the gunite tanks.

Path to Solution

- Complete performance evaluations of tank closure options for SRS Tank 19 with data on the cost, risk, and technical performance of preferred options.
- Develop recommendations on post-closure monitoring options consistent with the negotiated performance objectives for SRS.
- Initiate a joint TFA-ORR closure demonstration to transfer the knowledge and lessons learned from the SRS waste retrieval and closure demonstration.
- Build off of SRS and ORR experience to support the Hanford Tanks Initiative.
- Identify and evaluate closure performance objectives and technical options for Hanford Tanks 104-AX and 106-C, with stakeholder and user input.
- Provide technical, cost, and risk performance evaluation data to user to aid in determination of a preferred closure strategy for the Hanford Tanks Initiative tanks.

FY97-99 Scope

<u>SRS</u>

The main focus of these activities is support of Tank 19 in the F-Area tank farm, which is scheduled for closure by the end of FY97. Specific work scope will

- Evaluate disposal configuration options for tank closure. Specifically, a variety of alternative closure options for evaluation (in addition to grout over the waste) will be explored and source term conceptual models will be developed for the closure configurations chosen for evaluation. A concept study for treatment walls will be performed. Appropriate long-lived radio nuclide "getters" for inclusion in grout or treatment walls will be evaluated.
- Conduct a performance evaluation for selected preferred disposal options. For each closure configuration, permissible waste concentrations will be estimated. Permissible waste concentrations will be directly tied to quantitative regulatory performance objectives. Both the radionuclide and heavy metal components of the waste inventory will be evaluated for several different pathways such as groundwater, inadvertent intruder, and all pathways.
- Conduct a cost-benefit analysis to compare costs and risks of each evaluated preferred closure configuration.
- Recommend closure monitoring strategies based on results of the performance evaluation and cost/benefit analyses. A variety of active and passive monitoring schemes will be evaluated to develop a cost-effective post-closure monitoring scheme, which is focused on monitoring the appropriate site performance measures.

<u>Hanford</u>

The main focus of this effort is support of closure activities for Tanks 104-AX and 106-C as part of the Hanford Tanks Initiative. Specific work scope will

- Identify likely regulatory requirements and evaluate quantitative performance objectives based on these regulations.
- Determine various tank closure configurations with the site users and establish a baseline conceptual model of the near-tank environment, pathways, and receptors of concern, based upon previous characterization results and site assessments.
- Conduct scoping analyses to evaluate the performance and cost/benefit of various tank closure configurations and waste retrieval options for Tanks 104-AX and 106-C. Risk and permissible waste concentrations will be calculated for each preferred closure configuration and waste treatment/retrieval option.
- Conduct a study of alternatives for clean closure of the tank farms, evaluating options and technical feasibility of remediation of contaminated soils beneath and around tanks in the AX Farm, with and without removal of the tanks.
- Conduct a probabilistic assessment of health and safety risk to onsite workers, and to the general public, as a consequence of normal operations and postulated accidents for alternative closure assumptions.
- Develop information to support U.S. Nuclear Regulatory Commission's determination of residual waste classification for 104-AX, residual waste in 104-AX, and contaminated soil beneath 104-AX. Interaction with the U.S. Nuclear Regulatory Commission will also attempt to establish a definitive basis and process for classification of residual waste for future closure actions for Hanford's single-shell tank farms.

A joint TFA/Oak Ridge National Laboratory demonstration similar to the Waste Retrieval and Closure Demonstration at SRS will be initiated. The TFA will

- Provide technical expertise in the areas of developing closure criteria, performance objectives, and closure strategies. ORR will retain overall responsibility for the demonstration. The TFA will support transfer of the knowledge gained at the SRS (i.e., negotiations with regulators, closure criteria, and closure strategies).
- Partially support operations at ORR to implement tank closure.

Schedule
- Complete performance evaluation analysis and cost/benefit and risk analysis of preferred closure options for SRS Tank 19. Provide results to SRS users in support of closure strategy development (FY97). ***Implementation*** (AL26WT51-A)
- Identify post-closure monitoring strategies for SRS consistent with risk analysis (FY97). ***Implementation*** (AL26WT51-A)
- Complete performance evaluation and cost/benefit analysis of preferred closure preparation options for 104-AX (FY97). ***Implementation*** (RL07WT61-A5)
- Complete Assessment of Near-Field and Far-Field Contaminant Transport and Health Effects for AX Farm (FY97). ***Implementation*** (RL07WT61-A5)
- Complete Probabilistic Assessment of Health and Safety Risk to Workers and the Public for Postulated Accidents and Releases During Closure Preparation Operations, for Clean Closure and Landfill Closure Alternatives for 104-AX (FY98). ***Implementation***
- Complete preliminary performance evaluation and cost/benefit analysis of retrieval required for 106-C (FY98). ***Implementation***
- Complete Assessment of Near-Field and Far-Field Contaminant Transport and Health Effects for C Farm (FY99). ***Implementation***

- Complete recommendations on closure criteria and performance objectives and prepare a preliminary performance evaluation of recommended closure options to ORR (FY98). ***Demonstration***
- Submit detailed closure strategies and their corresponding Performance Evaluations to ORR (FY98). ***Demonstration***

Other Related Work

- Multiport Grout Injection (SCFA FY97)
- In Situ Grouting for GAAT Closure (TFA FY98, EM-30 (ORR) FY97)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA	450	2,280	1,150	
EM-40 (ORR)	305	1,000		
Total	755	3,280	1,150	

Problem Element Title: 1.3.1.7 Stabilize Tank for Closure

Problem Element Description

To prevent subsidence of a tank, collapse of the domed top, long-term migration of residual contaminants, or short-term release of residual waste contents due to catastrophic failure, stabilization of the tanks and installation of surface or subsurface barriers may be required following retrieval and post-retrieval characterization, but before final closure. Stabilization may encompass grout filling to fill and stabilize wastes, or simple gravel fill to prevent tank dome collapse. Barrier technology may include engineered surface barriers to prevent water, plant, and animal intrusion, or subsurface barriers that prevent contaminants or moisture from migrating downward to the water table.

Priority Site Needs

The FY96 site needs assessment process identified high-impact site needs within this problem element. Work activities have been proposed to directly address these specific need(s). These are identified in the table below as "primary" needs, and indicate that work activities will a) be closely coordinated with the cognizant engineers or technical points of contact at the identified site, b) likely involve use of actual wastes from that site, and c) result in products that will feed directly into the sites' technical and programmatic decisions. Work activities addressing a primary need may also have indirect benefit to related TFA site needs. These are identified in the table below as "secondary" and indicate that work activities will potentially provide valuable lessons learned and performance data that can aid in the site's technical planning and scope development; however, the work activities are not likely to provide results or data on site-specific wastes that could definitively support technical decisions. The primary needs being addressed and the secondary needs being partially supported within this problem element include

TFA Need Identifying No.	Site	Need Title/Description
Primary 546	Hanford	Testing of Capillary Breaks
547	Hanford	Getter Materials
578	Hanford	Long-term Testing of Surface Barrier
Secondary N/A		

Problem Statement

The original three site needs statements, as listed above, highlight a generic class of needs for the closure of HLW tanks. Taken together, these needs state that the Hanford site needs knowledge and concepts to characterize the soil surrounding the waste tanks and to stabilize the waste tanks, if required, by

- Adding materials that preferentially capture and retain out of the environment those radionuclides that contribute the most to the risk consequences of the waste residue in the tank.
- Developing data on potential barrier performances that can reduce the water recharge rates to the stabilized tanks. Numerous performance assessments have pointed to the recharge rate to the stabilized waste form as a major dose consequence driver.
- Developing concepts and designs that divert away any recharge water that penetrates the surface barrier to the stabilized tank site, to further reduce mobility of residue radionuclides.

Therefore, concepts, designs, and specific materials need to be developed that allow the tank(s) closed at Hanford to maximize the performance of its closure strategy to reduce to the maximum extent possible the eventual dose consequences of residue waste.

Path to Solution

- Assess current state-of-the-art in closure strategies and options.
- Develop new closure strategies based on regulatory performance requirements.
- Test and validate appropriate closure options for Hanford and other sites' use.
- Characterize the extent of soil contamination around Tank 104-AX.

FY97-99 Scope

This activity will investigate closure strategies that result in better retention of radionuclides in the stabilized waste tank. Specifically, this activity will

- Review state-of-the-art closure strategies, and develop and design new closure strategies and options based on negotiated closure requirements and performance objectives.
- Develop the validation data for these new strategies. A data base will be developed of closure options and their performance parameters will be developed to ensure an adequate decision base is available for the Hanford Tanks Initiative.

Schedule

- Survey and sample the vadose zone around 104-AX to determine extent of contamination as input to source term estimates and closure performance objectives (FY97). ***Implementation*** (RL07WT61-A2)
- Complete assessment of the state-of-the-art for tank closure (FY98). ***Engineering Development***
- Complete detailed designs and testing of new closure strategies and options (FY99). ***Demonstration***

Other Related Work

- Barrier Technologies (SCFA FY97)
- Getter Materials (Industry Program FY97)
- Soil/Groundwater Monitors (CMST)

Requested Budget

Funding Source	FY96 ($K)	FY97 ($K)	FY98 ($K)	FY99 ($K)
EM-50 TFA		700	600	1,000
Total		700	600	1,000

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

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSEE	Confined Sluicing End Effector
DOE	U.S. Department of Energy
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 Science and Technology (DOE)
FY	fiscal year
HLW	high-level waste
HTI	Hanford Tanks Initiative
INEL	Idaho National Engineering Laboratory (Idaho Falls, Idaho)
LA/MS	laser ablation/mass spectrometry
LDUA	Light-Duty Utility Arm
LLW	low-level waste
MYPP	multiyear program plan
ORR	Oak Ridge Reservation (Oak Ridge, Tennessee)

SRS	Savannah River Site (Aiken, South Carolina)
STCG	Site Technology Coordination Group
TFA	Tanks Focus Area
TRU	transuranic (waste)
TWRS	Tank Waste Remediation System
USG	User Steering Group

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

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 97-425) 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 (LLW)

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." By-product 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, Richland, Washington.

Site Technology Coordination Group (STCG)

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

This team develops the implementation plan and directs the Tanks Focus Area 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 National Laboratory is the lead) and the User Steering Group.

TFA Management Team

This team sets policy and provides 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

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 Tanks Focus Area.

TFA Technical Team

A group consisting of the Tanks Focus Area Technical Integration Coordinator, the five Technology 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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