TFA
TANKS
FOCUS AREA

Multiyear Program Plan
FY00-FY04

September 1999

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UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

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PNNL-12264
UC-600

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Pacific Northwest National Laboratory
Richland, Washington 99352

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Acronyms and Abbreviations

AEAT	AEA Technology
AM	assistant manager
AMP-PAN	ammonium molybdophosphate-polycrylonitrile
ASTD	Accelerated Site Technology Deployment Program
AWRS	Advanced Waste Retrieval System
BDAT	best demonstrated available technology
BVEST	Bethel Valley Evaporator Service Tank
CCD	countercurrent decantation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIF	Consolidated Incineration Facility
CNDE	Center for Non-Destructive Evaluation
CRB	Corporate Review Budget
CSEE	Confined Sluicing End-Effector
CMST	Characterization, Monitoring, and Sensors Technology Crosscutting Program
CPT	cone penetrometer
CPU	Compact Processing Unit
CST	crystalline silicotitanate
CUF	cells unit filter
D&D	decontamination and decommissioning
DDFA	Deactivation and Decommissioning Focus Area
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy-Headquarters
DSC	differential scanning calorimeter
DST	double-shell tank
DWPF	Defense Waste Processing Facility
ECR	effective cleaning radius
EIS	Environmental Impact Statement
EM	Office of Environmental Management (DOE)
EM-30	Office of Waste Management (DOE)
EM-40	Office of Environmental Restoration (DOE)
EM-50	Office of Science and Technology (DOE)
EMSP	Environmental Management Science Program
EN	electrochemical noise
EPA	Environmental Protection Agency
ESP	1) Efficient Separations and Processing Crosscutting Program, 2) Environmental Simulation Program
ESW	enhanced sludge washing
ETF	Effluent Treatment Facility
FETC	Federal Energy Technology Center

FFA	Federal Facilities Act
F&R	functions and requirements
FY	fiscal year
GAAT	Gunite and Associated Tanks
HAW	high-activity waste
HCI	Hanford Capsule Initiative
HEPA	high-efficiency air particulate (filter)
HLW	high-level waste
HTI	Hanford Tanks Initiative
ILAW	immobilized low-activity waste
INEEL	Idaho National Engineering and Environmental Laboratory (Idaho Falls, Idaho)
INTEC	Idaho Nuclear Technology and Engineering Center
IRB	Internal Review Budget
ITP	in-tank precipitation
LA/MS	laser ablation/mass spectrometry
LAW	low-activity waste
LDUA	Light-Duty Utility Arm
LLW	low-level waste
LRF	laser range finder
LVDG	low-volume density gradient
M&I	management & integration
MLDUA	Modified Light-Duty Utility Arm
M&O	management and operation
MPI®	multipoint grout injection
MST	monosodium titanate
MVCIT	Melton Valley Capacity Increase Tank
MVST	Melton Valley Storage Tank
MYPP	multiyear program plan
NDE	nondestructive examination
NDT	nondestructive testing
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
OBG	Old Burial Grounds
OHF	Old Hydrofracture Facility
O&M	operations and maintenance
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation (Oak Ridge, Tennessee)
OST	Office of Science and Technology (DOE)
PBS	Program Baseline Summary
PHMC	Project Hanford Management Contract
PI	principal investigator

QA	quality assurance
RBX	Robotics Crosscutting Program
RCRA	Resource Conservation and Recovery Act
REDOX	reduction-oxidation
RFP	request for proposal
RL	Richland Operations Office (DOE)
ROD	Record of Decision
SBW	sodium-bearing waste
SCFA	Subsurface Contaminants Focus Area
SREX	strontium extraction
SRS	Savannah River Site (Aiken, South Carolina)
SST	single-shell tank
STCG	Site Technology Coordination Group
TAG	Technical Advisory Group
TDI	Technology Deployment Institute
TFA	Tanks Focus Area
TIM	Technology Integration Manager
TMS	Technology Management System
TPA	Hanford Federal Facility Agreement and Consent Order (Tri Party Agreement)
TPB	tetraphenylborate
TRU	transuranic (waste)
TRUEX	transuranic extraction
T-SAFT	Tandem Synthetic Aperture Focusing Technologies
TTP	technical task plan
TWRS	Tank Waste Remediation System
USG	User Steering Group
WAPS	waste acceptance product specification
WIPP	Waste Isolation Pilot Plant
WVDP	West Valley Demonstration Project

Section 1 – Executive Summary

The U.S. Department of Energy (DOE) continues to face a major radioactive waste tank remediation problem with hundreds of waste tanks containing hundreds of thousands of cubic meters of high-level waste (HLW) and transuranic (TRU) waste across the DOE complex. Approximately 68 tanks are known or assumed to have leaked contamination to the soil. Some of the tank contents have reacted to form flammable gases, introducing additional safety risks. These tanks must be maintained in a safe condition and eventually remediated to minimize the risk of waste migration and/or exposure to workers, the public, and the environment. However, programmatic drivers are more ambitious than baseline technologies and budgets will support. Science and technology development investments are required to reduce the technical and programmatic risks associated with the tank remediation baselines.

The Tanks Focus Area (TFA) was initiated in 1994 to serve as the DOE Office of Environmental Management's (EM's) national technology development program for radioactive waste tank remediation. The national program was formed to increase integration and realize greater benefits from DOE's technology development budget. The TFA is responsible for managing, coordinating, and leveraging technology development to support DOE's five major tank sites: Hanford Site (Washington), Idaho National Engineering and Environmental Laboratory (INEEL) (Idaho), Oak Ridge Reservation (ORR) (Tennessee), Savannah River Site (SRS) (South Carolina), and West Valley Demonstration Project (WVDP) (New York). Its technical scope covers the major functions that comprise a complete tank remediation system: waste retrieval, waste pretreatment, waste immobilization, tank closure, and characterization of both the waste and tank with safety integrated into all the functions. The TFA integrates program activities across EM organizations that fund tank technology development, including the Offices of Waste Management (EM-30), Environmental Restoration (EM-40), and Science and Technology (EM-50 or OST).

The TFA depends heavily upon site users to participate in the TFA's multiyear planning and program execution. One of the key TFA organizational elements is the Management Team, led by DOE's Richland Operations Office (RL) and composed of federal user representatives from each of the five sites, plus DOE-Headquarters (DOE-HQ). The Management Team conducts weekly program updates, determines program policy, performs program prioritization, and performs program oversight. Through its DOE-HQ members, the TFA communicates with a HLW Steering Committee consisting of assistant managers from each of the five sites and DOE-HQ managers with radioactive tank waste remediation management responsibility.

For technical issues, the Pacific Northwest National Laboratory leads the TFA Technical Team that includes six additional laboratory partners. A User Steering Group (USG) that consists of senior contractor user members provides additional user representation to the program. Through its own technical review body, the Technical Advisory Group (TAG), the TFA receives high-quality, quick reacting, independent technical reviews.

Together, all the components of the TFA team execute a mission to deliver and work with users to implement technical solutions using an integrated approach to safely and efficiently accomplish tank waste remediation across the DOE complex. Inherent in the TFA mission, the TFA seeks to

- Provide technical solutions to enable and enhance remediation.
- Respond to the unique technical challenges inherent to the radioactive tank waste mission.
- Work with users and program partners throughout the remediation process, from problem identification to implementation of technical solutions.
- Focus on filling technical gaps and making tangible progress toward solving key tank problems.

To accomplish this mission, the TFA's goals include working to increase the use of EM-50 funded results, reduce programmatic and technical risk, and direct a portion of the program to contingency or alternative technology approaches. Several strategies are required to support the TFA's mission and goals. Meeting users needs, building and nurturing user-producer-developer teams, developing and executing a leveraged program, and providing a balanced portfolio of near- and long-term investments are among the key supporting strategies.

This multiyear program plan (MYPP) reflects the TFA's plan for the next five fiscal years (FY00-FY04). Most of the planning emphasis is on FY00 and FY01. During this period, the TFA plans major work in seven key areas. One of these areas, Characterization, is not listed separately below since it cuts across the other six areas. Characterization work is described, as appropriate, within these areas:

1) Safe waste storage
2) Waste mobilization and retrieval
3) Conditioning, transfer, and retrieval-pretreatment integration
4) Waste pretreatment
5) Waste immobilization
6) Closure.

Safe Waste Storage: Investments in safe waste storage are needed to fill technical gaps, reduce costs, and avoid costly problems, while ensuring protection of the public and environment. Priority site needs are focused on science and technology to 1) improve tank integrity monitoring and corrosion prevention, 2) improve tank ventilation, 3) improve waste characterization, and 4) reduce the volume of waste entering the tank farm through source and recycle stream waste reduction.

The TFA's near-term goal for assisting sites in avoiding tank corrosion is to improve upon methods for maintaining tank waste chemistry within site specifications by adapting commercial monitors for in-tank analysis of inhibitors and major species that control corrosion rate. The longer-term strategy for addressing tank corrosion includes development and assessment of corrosion monitoring methods that provide more direct and real-time measurement of the corrosion potential within a tank than do corrosion coupons. The strategy for evaluating tank integrity also includes near- and longer-term approaches. Commercial nondestructive examination (NDE) techniques will be deployed near term using an arm-based or crawler-based system to inspect tank walls. Longer-term efforts will integrate needs from multiple sites to define, develop, and test the specific systems needed to inspect tank floors, inspect surfaces below a liquid level, and assess a tank's integrity before reuse or waste retrieval.

To reduce the cost of active tank ventilation, the TFA is investing in regenerable filter systems and exploring commercial filtration technologies for high-temperature applications. Waste characterization investments include tools and methods to characterize waste in situ to support sludge and supernate processing at Hanford, SRS, and ORR. Investments are targeted at source and recycle waste stream volumes at SRS's liquid effluent treatment facility, mercury and chlorides removal at INEEL, and other waste minimization opportunities at INEEL.

Waste Mobilization and Retrieval: Improved or new methods to mobilize wastes and detect and mitigate leaks during waste retrieval operations constitute the TFA's major areas of emphasis in waste mobilization and retrieval. The TFA will continue its investigation of improved mixing and pumping technologies, to include potential developments available from the United Kingdom and Russia. The sites' concerns with waste leakage during retrieval operations are being addressed through a wide range of TFA activities that include improved control of water during retrieval, technologies for detecting leaks, and leak mitigation techniques in the event a leak is detected.

Conditioning, Transfer, and Retrieval-Pretreatment Integration: The sites face several problems between the time waste is retrieved and before pretreatment. The TFA will continue its investigation of waste re-precipitation, solids formation, waste transfer line plugging, and settling. This work includes monitors that report the condition of the waste and adapting and testing systems that unplug pipe blockages. Thermodynamic and kinetic laboratory studies will increase the knowledge of waste characteristics and properties during the time between retrieval and pretreatment. These studies should produce results that have implications on both the retrieval and pretreatment operations.

Waste Pretreatment: Waste pretreatment is used to separate radionuclides into small volumes of HLW (which require more expensive immobilization and disposal), while leaving the majority of chemical wastes for less costly disposal as low-activity waste. The TFA's investments include clarifying liquid streams through solid-liquid separations, supernate processing to remove radionuclides, and sludge processing to remove excess chemical species that either increase the volume of HLW or adversely impact the performance of the HLW form.

Waste Immobilization: The TFA will continue to support the sites' requirements for improvements to ongoing immobilization operations and the privatization of waste treatment. The TFA's work will assist DOE in measuring contractor performance and identifying expected waste performance characteristics that result from the contractors' immobilization operations. This wide-ranging work includes studies and tests on glass formulations, waste product performance, feed preparation, improved melter designs, more efficient and productive melter operations, and remote maintenance, decontamination, and decommissioning of melter equipment.

Closure: The TFA will continue to assist sites in stabilizing and closing their tanks. Based upon past success in grouting operations, the TFA will continue to invest in improved grout formulation and better develop bases for tank closure. Based on site needs, the TFA is investing in vadose zone contamination issues and those related to residual tank wastes. The TFA integrates a wide range of activities from other EM-50 programs directed at solving these problems. These activities include characterization, retrieval, and in situ grouting systems.

To support all of the work summarized above, the TFA, in concert with the user community it serves, developed technical approaches to solve problems and to define the supporting funding requirements. Table 1.1 presents a 5-year funding summary for technical work (does not include management costs). Formulation of this funding summary began with the development of technical responses to site needs received during FY99. The stated FY00 funding is the approved TFA budget total. The FY01 funding consists of the approved FY01 Corporate Review Budget (CRB) at the Target Level. The FY02 - FY04 totals are the result of a functional analysis of expected future requirements based on baseline assumptions and present site needs.

The TFA formally updates its requirements with its users annually and routinely makes program adjustments as soon as new requirements are identified or when previous requirements become satisfied or are no longer a priority.

This MYPP presents the recommended TFA technical program. The recommendation covers a 5-year funding outlook (FY00-FY04), with an emphasis on FY00 and FY01. The MYPP describes the tank waste remediation problem and TFA's role in solving it (Section 2), the TFA's vision and mission (Section 3), the goals and strategies required for TFA to succeed (Section 4), the relationships between the TFA and its program partners (Characterization, Monitoring, and Sensor Technology Crosscutting Program; Efficient Separations and Processing Crosscutting Program; Robotics Crosscutting Program; Accelerated Site Technology Deployment Program; Environmental Science Management Program; and Industry, University, and International Programs) involved in deploying innovative technologies and providing critical data (Section 5), the TFA's technical program (Section 6), and references used in the work (Section 7).

As supporting material, this report contains the TFA's organization (Appendix A), paths to closure data (Appendix B), a description of the TFA's prioritization process, including the

Integrated Priority Listing (Appendix C), major milestones (Appendix D), crosswalk tables of work packages to budget formulation product lines and technical responses to problem elements (Appendix E), partner programs (Appendix F), descriptions of the five major tank sites (Appendix G), and a glossary (Appendix H).

Table 1.1. TFA and Other EM-50 Funding, FY00-FY04

	FY00	FY01	FY02	FY03	FY04
TFA	32.887	40.185	45.4	45.6	45.2
Other EM-50	7.285	10.636	13.7	15.7	14.1
Total	40.712M	50.821M	59.1M	61.3M	59.3M

Section 2 - Program Background and Problem Description

2.1 Problem Description

Remediation of tanks containing highly radioactive waste is a major technical and programmatic challenge for the DOE (Stewart et al. 1997). The DOE system currently stores about 340 million liters of waste containing more than 700 million Curies (MCi) in 282 tanks at five major sites:

- SRS near Aiken, South Carolina, has 51 tanks (two closed) storing 125 million liters of waste containing about 400 MCi of radioactivity.
- In Washington State, the Hanford Site has 177 tanks that store 208 million liters of waste containing about 200 MCi of radioactivity.
- INEEL near Idaho Falls, Idaho, has 11 tanks with 5.3 million liters of liquid waste containing 520,000 Ci of radioactivity and 3.8 million liters of calcined (a granular powder) waste with 24 MCi of radioactivity stored in seven bin sets.
- ORR in Oak Ridge, Tennessee, has about 1.6 million liters of legacy waste containing 47,000 Ci of radioactivity in 40 tanks. ORR also annually adds approximately 56,000 liters of active waste containing 13,000 Ci of radioactivity to 13 of their tanks.
- WVDP near West Valley, New York, has retrieved and vitrified approximately 95% of the 2.3 million liters of waste that was stored in 3 tanks.

In addition to the 282 tanks within the TFA's purview, each site also contains miscellaneous storage tanks. While not one of the five "official" TFA tank sites, the TFA provides technical assistance, as needed, to the Fernald Environmental Management Project (Ohio).

The wastes are chemically and physically heterogeneous between sites, between tanks on a given site, and in some cases, between the phases of waste within a single tank. Tank wastes at Hanford, SRS, ORR, and WVDP are alkaline. At Hanford and SRS, these wastes resulted from chemical separations operations required to produce plutonium. Hanford used several different separations processes over the years of plutonium production and additional operations such as uranium, cesium, and strontium recovery. As a result, there are several different waste types at Hanford. WVDP wastes were generated from commercial reprocessing of uranium and plutonium from spent nuclear fuel. ORR wastes are similar in composition to some of the wastes at Hanford and SRS; during World War II, ORR developed and demonstrated many of the chemical separations processes used at those sites. INEEL's waste type is unique within the DOE system in that it is stored in an acidic form. The majority of INEEL's waste has been calcined, which is considered an interim storage form by the State of Idaho. Calcine waste requires further processing to convert it to a more durable long-term waste form. In addition, the INEEL has some tank heel waste remaining that must be addressed (see Appendix G for more details). Much of the waste at Hanford, SRS, and WVDP is classified has high-level waste (HLW).[1] The waste at ORR is mixed low-level waste (MLLW) or transuranic waste (TRU) (Schulz, 1998).[2,3]

To protect the public, workers, and the environment, this radioactive waste must be safely stored, retrieved from the tanks, and converted into an appropriate form for long-term disposal. DOE has signed Federal Facility Agreements (FFAs) with state and Federal regulators that drive the scope and schedule for cleanup and closure of the tanks. Based on DOE's "*Accelerating Cleanup: Paths to Closure*" document (DOE 1998) that outlines the activities, cost, and schedule for EM cleanup, the HLW mission area represents the highest cost driver for EM (32% of the total life-cycle cost). In addition, HLW remediation is a long-term problem, with 74% of the cost to be incurred after 2006. The life-cycle cost for HLW remediation is estimated as $47B. Cost, schedule, number of waste streams, and number of Project Baseline Summaries (PBSs) with urgent or high technical risk and high visibility are summarized for each site in Table 2.1.

Each site is at a different stage in remediation of wastes and closure of tanks. SRS and WVDP have operating waste immobilization facilities, while Hanford, INEEL, and ORR are designing and preparing for future processing to convert tank wastes into final waste forms for disposal. Hanford and ORR are pursuing contracts where private companies will build and operate the processing facilities. ORR and WVDP have retrieved or consolidated the majority of their bulk wastes for treatment and are focused on residuals removal and tank closure. SRS is continuing sludge and heel retrieval for immobilization in the Defense Waste Processing Facility (DWPF) and to continue tank closures. Hanford is preparing for waste retrieval to support feed delivery to the privatization contractor, while INEEL is focused on an accelerated schedule to assess the various options for tank waste treatment and facility disposition.

SRS must meet high-level waste canister production schedules by maintaining and improving the DWPF operations. However, the baseline process for removal of cesium and other radionuclides from retrieved salt solutions (a precursor to DWPF processing of salt waste) was discontinued in 1998 due to technical problems and safety concerns. Therefore, a salt disposition treatment alternative is required to enable future processing and immobilization. Meanwhile, continued retrieval of sludge wastes is required to maintain a non-salt feed to the DWPF. In addition, regulatory commitments require continued efforts to close tanks.

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[1] High-level waste is defined as waste from the reprocessing (chemical separation) of uranium and plutonium from other nondesired radioactive elements. High-level waste contains most of the radioactive elements discharged as waste to the underground tanks.

[2] Mixed waste contains both hazardous chemical and radionuclide components. Mixed low-level waste contains hazardous chemicals and low-level waste. Low-level waste is defined as radioactive waste not classified as high-level waste, transuranic waste, spent fuel, or byproduct material.

[3] Transuranic waste has alpha-emitting elements that have atomic numbers greater than 92 with half-lives greater than 20 years in concentrations of more than 1 ten-millionth of a curie per gram (0.03 ounce).

Table 2.1. Summary of Paths to Closure Data on High-Level and Tank Waste Remediation Mission

Site	Cost, \$B[1]	Complete Date	Waste Streams	Number of PBS	PBS High Visibility
Hanford Site	30.0	2046	3	5	5
Savannah River Site	11.0	2028	21	7	2
Idaho National Engineering and Environmental Laboratory	4.8	2070	4	3	3
West Valley Demonstration Project	1.1[2]	2005[2]	4	2	2
Oak Ridge Reservation[3]	3.2	2006	2	3	3

Reference: For cost and completion date: U.S. Department of Energy. 1998. *Accelerating Cleanup: Paths to Closure.* DOE/EM-0362, U.S. Department of Energy, Washington, D.C. Waste stream and PBS information derived from sites' Spring 1999 Paths to Closure update submissions.

[1] Costs accrued from FY97 through completion date.

[2] Final costs and facility closure completion date TBD.

[3] Non-HLW site. ORR tank remediation costs not included in HLW cleanup totals.

Hanford is preparing to retrieve wastes and deliver tank waste feed to a privatization contractor for pretreatment and immobilization. The site will then accept immobilized low activity and high activity waste products from the vendor. Hanford must ensure that the waste feed is available, can be delivered on time, and meets contractual requirements. A product acceptance strategy is required to ensure vendor products meet regulatory requirements for disposal. This privatization contract, known as Phase I, represents treatment of approximately 10% of the site's tank waste. The remaining tank waste will be processed later, during Phase II. Phase II will also include waste treatment by private contractors, and may include privatization of other tank waste remediation operations, such as retrieval. Results of Phase I will help define requirements for Phase II. Meanwhile, Hanford must maintain safe storage conditions for wastes in the double- and single-shell tanks. For example, salt-well pumping operations must be continued to transfer the liquids in the single-shell tanks to double-shell tanks, thereby reducing corresponding risks of leakage to the vadose zone.

INEEL must continue efforts to design and test an integrated flowsheet for low-activity and high-activity waste processing to meet the compliance schedule for Title 1 design. Although all liquid HLW has been converted to a dry storage form (i.e., calcine) for interim storage, future processing will be required to produce an acceptable final waste form. Flowsheet elements may include dissolution of calcined wastes, separation of transuranics, cesium, and strontium, and immobilization of the low-activity and high-activity fractions. An Environmental Impact Statement (EIS) is being prepared at this time to provide a basis for deciding the technical options to process the INEEL tank waste. Testing of flowsheet unit operations, downselection to preferred options, and integrated design and testing of the pretreatment and immobilization processes are required to support the design schedule. To meet recent consent order requirements, INEEL is also accelerating efforts to inspect and permit storage tanks needed for future activities, and close the HLW tanks not needed to complete the site mission.

ORR is continuing efforts to retrieve and consolidate all tank wastes at a single facility for processing by a privatization contractor. Retrieval and transfer operations have been completed or are underway for all of the tank farms consistent with regulatory commitments. Continued deployment of mixing, mobilization, heel retrieval, cleaning, waste conditioning, volume reduction, and monitoring technology is required to complete the retrieval, consolidation, and feed delivery efforts. Closure of tanks is required to further reduce mortgages and meet ORR cleanup schedules.

WVDP has completed bulk retrieval and processing of the primary tank wastes and is preparing for closure activities, including decontamination and disposal of waste materials and expended equipment. Glass-contaminated equipment from HLW vitrification operations must be decontaminated if it is to be disposed as LLW. HLW canisters require decontamination to enable off-site shipment and disposal. The site is also completing tank heel retrieval and preparing for tank closure activities to meet compliance schedules and support the development of a final tank closure strategy.

SRS, Hanford, INEEL, ORR, and WVDP require technical assistance, scientific data, technology development, and baseline technology performance verification to improve efficiency, reduce costs, reduce risks, and enable the baseline tank waste remediation and closure activities outlined above to be implemented. In addition, because HLW remediation represents the greatest cost and longest term EM problem, there is a greater potential for significant impact from science and technology. Scientific research and applied technology activities focused on longer-term, high-risk and high-cost portions of the HLW processing flowsheets are required to support future decisions on baseline and alternative remediation strategies (NRC, 1999).

2.2 Functions to Solve the Problem

Before FY95, responsibility for developing technical solutions to support tank remediation was spread across multiple EM organizations and sites. In January 1994, DOE issued an action plan establishing a new approach for solving complex remediation problems, including highly radioactive waste tank problems. On April 1, 1994, DOE issued a call for proposals on approaches for transitioning tank technology from a distributed to a focused national effort.

A team of seven contractors and national laboratories responded to and were awarded the responsibility to implement the Focus Area concept for radioactive waste tanks. This concept includes leadership through a partnership between DOE-RL and the Pacific Northwest National Laboratory. It also includes partnerships between users and technical experts to define and execute an integrated, Focus Area-centered program.

This concept has been put into practice for the last five fiscal years. The key attributes of this concept include:

- Integration with the users
- Technical centers of excellence
- Focus Area-centered concept
- Technical assistance to users.

Integration with the users: The EM-30 and EM-40 users on both the DOE and the contractor sides are active members of the TFA. The TFA organization is shown in Figure 2.1, with details of membership in Appendix A. Both the TFA Management Team and the HLW Steering Committee represent the users. The TFA Management Team consists of DOE users from the five tank sites and DOE-HQ. Their role is to ensure needs are developed and submitted through the Site Technology Coordinating Groups at their sites, to prioritize the technical responses to those needs, and to help ensure site contractors are incentivized to include TFA technical solutions in their baselines. Additionally, the DOE user members of this team act as liaisons to their managers for EM-30 and EM-40 on specific TFA activities and products.

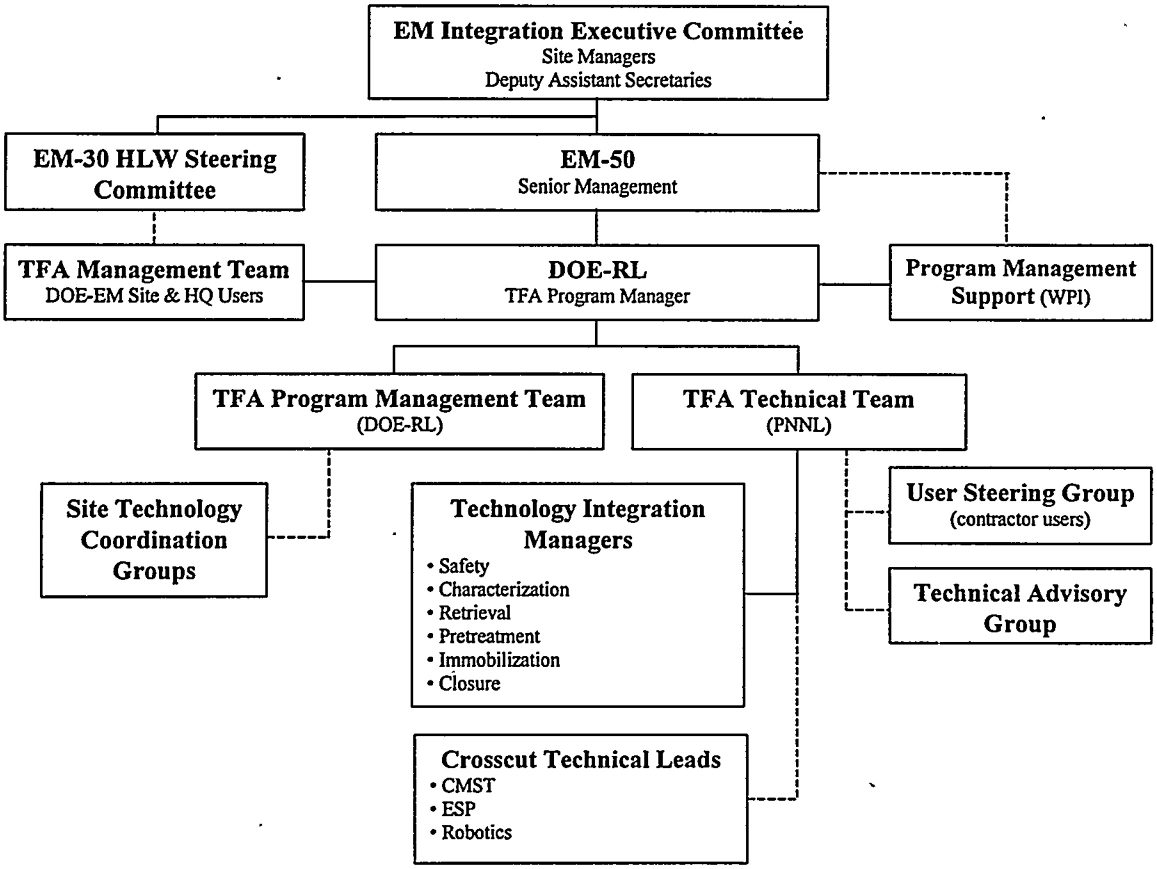


Figure 2.1. Tanks Focus Area Organization

These managers and Headquarters managers with HLW responsibilities comprise the HLW Steering Committee. This committee ensures complex-wide integration on policy and other issues including science and technology. Members of the HLW Steering Committee have been signatories on the TFA Multiyear Program Plan starting in FY97. The combination of the day-to-day management attention from the user program provided through the TFA Management Team and the endorsement of the HLW Steering Committee has allowed TFA to stay aligned with user needs and schedules. This helps lead the TFA to deploy and implement several key technical solutions, resulting in significant progress by EM in resolving tank problems.

Integration with the users also requires active participation with the implementing contractors at each of the sites. As a result, a User Steering Group (USG) participates with the TFA. The USG is comprised of managers from the five management and integration or management and operations organizations at each of the sites, plus managers from the laboratories that participate on the TFA. This group ensures that the technical and programmatic details required to fully define site needs are provided, that barriers to deployment of technical solutions are mitigated within the contractor organizations, and that site resources are provided to ensure implementation of technical solutions.

Integration of the TFA Management Team and the USG into site planning and resource allocation results in delivery and implementation of technical solutions to solve users' key problems.

Centers of excellence: The TFA is constructed on a partnership between the DOE and the national laboratories to ensure technical excellence in both the translation of a need to a viable technical solution and the execution of the program in a technically sound manner. This partnership is illustrated in Figure 2.1. The Technical Team is led by the Pacific Northwest National Laboratory and includes six laboratory or government contractor partners that provide technical leaders in the key functional areas associated with tank waste remediation: Los Alamos National Laboratory provides safety leadership, INEEL provides characterization leadership, Numatec Hanford Corporation provides retrieval leadership, Oak Ridge National Laboratory (ORNL) provides pretreatment leadership, Westinghouse Savannah River Company provides immobilization leadership, and Sandia National Laboratories provides closure leadership. The Technical Team provides the technical expertise and deployment experience required to develop technical scope, maintain technical progress, and ensure delivery of technically responsive products to the user. In addition, the three crosscut programs – Characterization, Monitoring, and Sensor Technology (CMST); Efficient Separations (ESP); and Robotics (RBX) represent additional centers of excellence for the crosscutting areas that support tank waste remediation and other EM mission areas. Crosscut program technical leads work with the TFA's Technology Integration Managers (TIMs) to develop and implement the technical program.

Focus Area-centered: The TFA encompasses 11 science and technology-related programs within EM that range from the applied research conducted by Environmental Management Science Program (EMSP) to the site programs that focus on site-specific issues. As needs are received, the TFA works to identify not only the appropriate technical response, but also the most qualified program to perform the work scope. The TFA then ensures integration and coordination of all of the products from these 11 programs in a way that leads to single-point delivery of technical solutions to the user programs. This approach clarifies and tracks the interfaces in a systematic manner, avoids duplication of technical investments, and enables deployment and implementation by providing the coordination required to deliver solutions. In this way, the TFA is the single point of accountability for tank science and technology and acts as a focal point for user interface and science and technology information.

Technical assistance to users: The network of users and technical experts provided by the TFA organization has provided and will continue to provide technical assistance to the five tank sites plus the Fernald Environmental Management Project as needed. Frequent technical exchanges on key topics have occurred and are planned in the future to ensure rapid dissemination of lessons learned as technical solutions and technologies are deployed. This approach has increased the likelihood of multiple deployments. Moreover, technical experts - including those from the TFA's TAG, which serves to review many aspects of the TFA program - are providing technical assistance through consultation and reviews for key activities at each site as needed. Examples include privatization at Hanford, flowsheet development at INEEL, and alternatives for tank salt processing at SRS.

Section 3 – Vision and Mission

This section describes the TFA's mission and vision within the context of the EM-50 mission. This section also discusses the direct correlation between the five elements of EM-50's Focus Area-centered approach and the TFA's mission and operational approach.

3.1 Vision and Mission Statements

The vision of EM-50 (the principal organization responsible for creating and funding the Focus Areas) is to provide the scientific foundation, new approaches, and new technologies that contribute to significant reductions in risk, cost, and schedule for completing the EM mission. The TFA's vision is aligned with EM-50's vision. The TFA's vision is to enable EM's goal of tank farm closure through the development and application of safe and efficient remediation technologies.

The mission of EM-50 is to manage and direct targeted basic research and focused, solution-oriented technology development programs to support EM. Within this mission, the TFA's mission is to

> **Work with users to deliver, develop and implement technical solutions — through an integrated approach — to safely and efficiently accomplish tank waste remediation at five major DOE sites: Hanford Site, Idaho National Engineering and Environmental Laboratory (INEEL), Oak Ridge Reservation (ORR), Savannah River Site (SRS), and West Valley Demonstration Project (WVDP).**

Inherent to this mission, the TFA seeks to

- Provide technical solutions to enable and enhance remediation.
- Respond to the unique technical challenges inherent in the program's mission.
- Work with users and program partners through the entire process, from problem identification to implementation of technical solutions.
- Focus on filling technical gaps and making tangible progress toward solving key tank problems.

3.2 Relation to the Focus Area-Centered Approach

Under the Focus Area-centered approach, the TFA leads the integration of EM-50's technology development that supports tank waste remediation. Five key elements distinguish the Focus Area-centered concept. These five elements are presented below, including a short description of the TFA's support to them.

1) **Integration.** The TFA maintains continuous contact with other EM-50 programs in developing and executing technology development work supporting tank waste remediation. For the TFA, these programs include Crosscutting, Industry, International, University programs, and the Accelerated Site Technology Deployment (ASTD) program. The TFA maintains close relations with the Environmental Management Science Program (EMSP), the TFA's link to supporting basic research. For each of these programs, the TFA strives to ensure planned and ongoing technology development work supports users' needs effectively, efficiently, and without duplication. (See Section 5.0 for more information on partner programs).

2) **Expanding the Technical Assistance Role.** The TFA seeks to be proactive in solving technical problems. Beginning with its analysis of users' technology development needs, the TFA maintains an interactive posture with each user. The TFA's goal is to not only ensure that each site need is understood, but also to ensure that the user fully understands the ramifications of each need. During needs analysis, the TFA attempts to identify technology gaps that should be brought to the attention of the user. Exposure of these technology gaps provides the user with a broader understanding of the technical problem to be solved and potential solutions.

   Throughout any year, the TFA seeks to lead technical exchanges between technical researchers and users. In the past, various TFA-led or TFA-sponsored workshops, such as the Immobilization-Pretreatment Integration Workshop and the Retrieval-Closure Workshop, provided complex-wide technical assistance.

3) **Maintaining the Highest Technical Capability.** The TFA consists of a network of the most highly qualified federal and contractor technical and program management experts. The TFA's technical core is drawn from seven contractors and national laboratories that regularly contribute to the program (see Appendix A). The TFA's User Steering Group (USG), Technical Advisory Group, and independent peer reviews ensure that the performers work meets the users' needs and is of the highest quality. The TFA uses a performer selection logic to select top quality organizations and principal investigators to carry out the TFA's technical work. The logic assists the TFA in designating the best organization to perform a task, whether commercial or government, based on qualification, regulatory, schedule, and cost considerations. Following the performer selection logic also helps the TFA determine whether or not to compete new TFA workscope.

4) **User Connection.** The TFA is a consensus-driven program that formally includes users throughout program development and execution. The TFA's annual program cycle includes users throughout the process, including the annual program kickoff activities, technical response development to users' needs, the annual program prioritization meeting, midyear review, and the Program Execution Guidance/Technical Task Plan review meeting. Weekly telephone conferences of the TFA's Management Team keep users abreast of key technical and programmatic developments.

5) **Communication of Science Results.** In communicating science results, the TFA serves at least two roles. In the first, the TFA helps define to EMSP (program managers to principal investigators) the HLW science needs and how existing science projects can help solve present site science and technology needs. In the second role, the TFA provides a conduit for communicating back to the sites, significant results from ongoing projects. Through the TFA's interactions with EMSP and the various HLW-related projects, the TFA incorporates significant results into its technical responses and technical approaches that respond to site needs.

Section 4 – Goals and Strategies

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 to remediate radioactive waste tanks. The program strives to be consistent with DOE's accelerated cleanup plan and enables EM to meet its goals for processing waste (e.g., number of canisters per year) and closing tanks (e.g., number of tanks closed per year).

This section presents the strategic intent of the program through an explanation of the program's goals and strategies.

4.1 Goals and Strategies

The TFA uses three goals to guide program development and execution. These goals are under constant revision; however, the present set is a product of reflection on the TFA's past and present program and an assessment of future requirements, all developed and coordinated with site users.

Goal #1: Increase use of EM-50-funded results so that 70-90% of products are being used. The key point of the goal is to *increase* the use of EM-50-funded technologies. While the desired percentage of increase may be debated, *increasing* the percentage is most important. To attain this goal, the TFA is committed to the following strategies:

- Deliver technology, as defined, on schedule.
- Construct and maintain a leveraged program.
- Emphasize user/producer/developer teams.
- Understand functions, requirements, and schedule.
- Bridge the gap between fundamental science and technology implementation.
- Identify and build user relationships.

Goal #2: Reduce programmatic and technical risk. The TFA seeks to reduce risk for both the user and EM-50. Essential elements of this goal are the constant pursuit of multi-site technology applications focused on high priority, high risk needs of the users; and the selection of the best technical performers available to most effectively address technical risk issues. To attain this goal, the TFA commits to the following strategies:

- Maximize multi-site benefits from technology investments and focus on activities with the greatest technical impact.
- Develop national laboratory-industry partnerships to respond to needs, ensure scientific and technical excellence, and deploy technologies.
- Manage the budget, budget change processes, and site prioritization influences to respond quickly to changes in sites' programmatic risks.

- **Goal #3: Develop a TFA program portfolio that permits development of contingency or alternative technology approaches in response to site needs.** As a proactive technology development program, the TFA uses its technical expertise to anticipate problems and risk-reducing technical solutions, even into the outyear planning calendar. Through this goal, the TFA seeks to offer alternative technologies and actively accommodate technological contingencies to the DOE complex. During the next year, the TFA will work with its user community to better define portfolio management principles the TFA should adopt that will result in advocacy and endorsement in these "strategic" investments.

4.2 Support to EM's Major Science and Technology Thrusts

Strategies to attain each TFA goal directly support EM's four major thrusts for science and technology investment.

1) Accelerate technology deployment. To support this thrust, the TFA is committed to the following strategies:
    - Deliver solutions on time.
    - Thoroughly understand users' needs.
    - Seek multi-site benefits.
    - Develop national laboratory/industry partnerships.
    - Ensure goals and strategies reflect users' needs.
    - Pursue strategic investments.
2) Reduce cost. To support this thrust, the TFA is committed to the following strategies:
    - Leverage other technical tasks, whether TFA-funded or not.
    - Build quality user/producer/developer teams.
    - Deploy technologies at multiple sites or for multiple purposes.
    - Skillfully manage the TFA budget.
    - Ensure programmatic goals and strategies meet user needs.
3) Meet high priority needs. To support this thrust, the TFA is committed to the following strategies:
    - Ensure complete communication between users, producers, and developers.
    - Manage the gap between fundamental science and technology implementation.
    - Continually build relationships with users.
    - Nurture national laboratory-industry partnerships as a catalyst to more effectively and efficiently respond to users' needs.
    - Manage the technical task prioritization process to ensure the highest priority needs receive available funding.
    - Develop and maintain program goals and strategies that support high-priority needs.
    - Strive to provide a balanced portfolio of near- and long-term investments.

4) Reduce EM's technological risk. To support this thrust, the TFA is committed to the following strategies:
   - Consider all risk from fundamental science to technology implementation.
   - Take advantage of successful technology implementations through lessons learned and practical multi-site or multi-use implementations.
   - Develop national laboratory-industry partnerships that can result in technology breakthroughs.
   - Consider risk-based performer selection and task prioritization criteria.
   - Maintain risk as a component of the TFA program goals.
   - Be proactive in strategic investments and technical assistance.

Section 5 – Relationship to Other Programs

The TFA maintains continuous working relationships with other EM-50 programs including:

- Characterization, Monitoring, Sensor Technology (CMST) Crosscutting Program
- Efficient Separations and Processing (ESP) Crosscutting Program
- Robotics Crosscutting Program (RBX)
- Industry Programs
- University Programs
- International Programs
- Accelerated Site Technology Deployment (ASTD) Program
- Environmental Management Science Program (EMSP)
- Other Focus Areas

For each of these programs, the TFA strives, through its integration role, to ensure planned and ongoing technology development work supports users' needs effectively, efficiently, safely, and without duplication. The primary reason the TFA invests in technology development activities is to reduce the risks associated with tank waste remediation. Risks include environmental, safety, and health risks to workers and the public; ecological risks; cost and schedule risks; programmatic risks; and technical risks. The strategic intent of the TFA is to work closely with the tank site user programs and the Site Technology Coordination Groups (STCGs) to develop a risk-based prioritization of technical responses to site needs and invest wisely in those responses. (Please refer to Figure 2.1, Tanks Focus Area Organization.)

The TFA's strategic intent is to leverage every available investment in science and technology made by DOE and, in doing so, engage the entire intellectual capacity of the nation in addressing the high-level waste problem area. In the model illustrated in Figure 5.1, each element in the technology maturation cycle 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 science and technology solutions flow downstream to the user. However, users are the ultimate customer and can directly benefit from any "upstream" program. Deployment plans and memorandums of understanding formalize the TFA's commitment to user, producer, and developer partnerships across sites regarding test variables and results that must be obtained to meet multi-site requirements and ensure technology implementation.

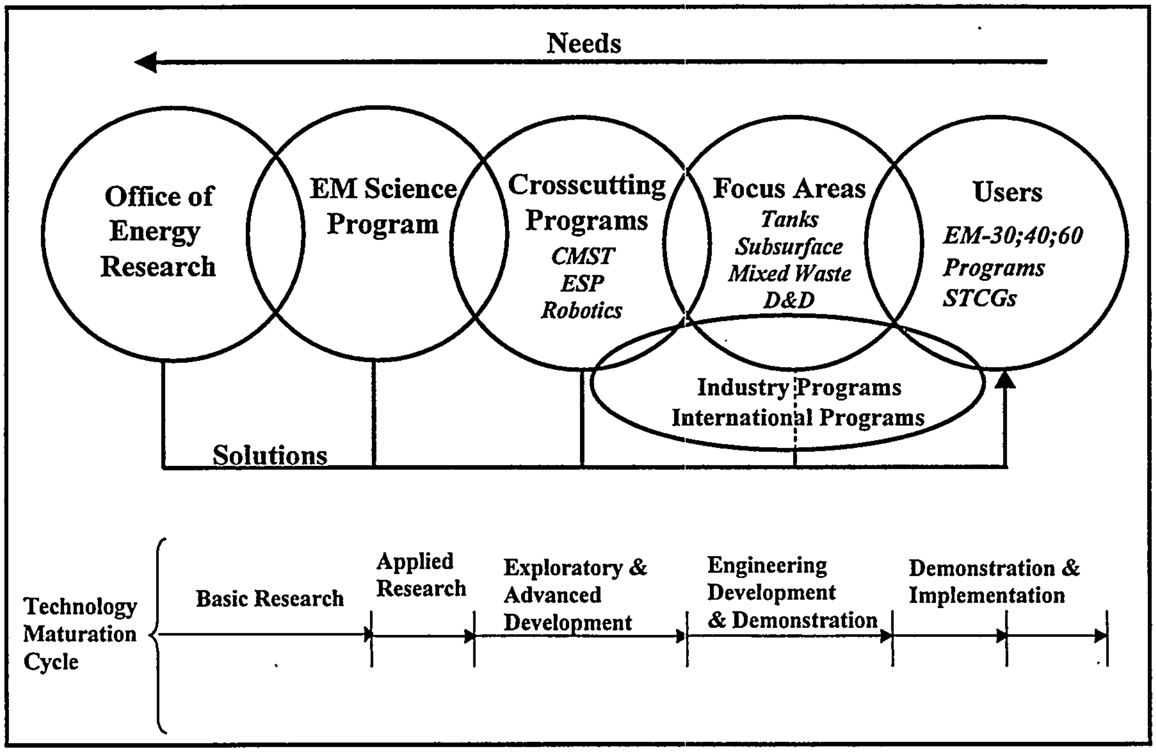


Figure 5.1. Tanks Focus Area Conceptual Strategy Model

In FY00, the TFA will continue to be responsible for the scope, schedule, and budget of EM-50's high-level tank waste remediation program described in this MYPP. The TFA will coordinate tank waste-related work conducted by EM-50 crosscutting programs, ASTD, EMSP, International, Industry, and University Programs as well as related work being conducted by other Focus Areas and by each of the site's EM-30 or EM-40 programs. The TFA envisions greater management of a single program that crosses organizational boundaries, with the TFA-managed scope covering HLW technology work with potential multi-site applications (see Appendix H which lists other EM-50 program support for FY00 and FY01). While site-specific technology will continue to be managed by each site, the TFA will be cognizant of all tank technology activities within EM to provide technical assistance across sites, support site negotiations, and manage technical uncertainties with practical technical expertise. Additionally, the TFA remains cognizant of the activities in the other Focus Areas (Subsurface Contaminants; Mixed Waste; Nuclear Materials and Deactivation and Decommissioning) and leverages, where applicable, other focus area activity to provide solutions to HLW technology needs.

5.1 Crosscutting Programs

The TFA actively engages and coordinates the efforts of EM-50's crosscutting programs – ESP, CMST, and RBX. The TFA is the customer for HLW technologies developed in these programs and facilitates the technologies' transition through the stage-gate framework from development to implementation. As such, the TFA requests support in areas consistent with its priority tasks (see Appendix C) and actively works with these programs to review and transfer these technologies. This "Focus Area-centered" approach requires routine interaction and an increased level of cooperation between the TFA and the crosscutting programs. To facilitate cooperation, technical experts in each crosscutting program have been assigned to interface with the cognizant Technology Integration Manager within TFA. Annual meetings, technical seminars, workshops, and administrative planning are some of the means by which the integration is accomplished.

Examples include:

- ESP's development of a single-step process for removal of TRU, Sr, and Cs at INEEL (see Section 6, Problem Element 1.2.2.5).
- CMST's development of Raman-based nitrate, nitrite, and hydroxide in-tank sensor for corrosion inhibitor concentration at Savannah River (see Section 6, Problem Element 1.1.1.1).
- Robotic's development of remote technologies to enhance cleaning, decontamination, and reconfiguration of Hanford jumper pits (see Section 6, Problem Element 1.4).

5.2 Industry Program

Industry's contribution to the TFA is secured through DOE internal contracts or DOE external competitively bid industrial contracts. The former process historically involved a DOE internal bid consisting of a consortium of entities, including industry, management and integration (M&I) contractors, management and operations (M&O) contractors, national laboratories, or universities with a DOE grant. Internal partnering occurs when an existing DOE contractor solicits a partner for co-bidding a DOE project, or an industrial company approaches an existing DOE contractor to partner on an internal DOE solicitation for bids. The response to these calls must come from the DOE contractor who represents the consortium. Normally, these calls are limited to M&Os, M&Is, and national laboratories, universities with environmental research and development programs that are recognized and supported by DOE.

Direct external contracts between TFA and industry are secured through a specific site procurement office (DOE or contractor) or through the DOE Federal Energy Technology Center (FETC) procurement office. The TFA does not directly request proposals nor does it accept unsolicited proposals. Rather, industrial partners are encouraged to communicate through FETC on all proposals, solicited or unsolicited. Responses or inquiries to requests for proposals (RFPs) solicited through an operating office or a support contractor should be directed to the issuer of the request. The DOE operations offices and DOE site contractors follow the Federal Acquisition Regulations and DOE Acquisition Regulations and use prescribed contractual procedures, which vary from site to site. Therefore, industry partners are encouraged to become familiar with the requirements of the site of interest before responding to RFPs.

An example of Industry Program's support to the TFA is the acquisition of a commercial regenerable filter system to replace HEPA filters used in active site ventilation systems (see Section 6, Problem Element 1.1.2).

5.3 International Program

The TFA's strategic intent for the International Program is to leverage opportunities and coordinate DOE's foreign investments in technology, performance data, and resources that relate to tank waste remediation needs. This is accomplished through joint definition between the TFA and the user of the validated needs, negotiation of scope and deliverables with the international performers, and delivery and implementation of the final equipment to meet the users' schedules. The TFA requests support in areas consistent with its priority tasks (see Appendix C) and actively works with International Programs to review and transfer these technologies.

On behalf of the TFA, the International Program is supporting Russian involvement in the development of a single-step process for removal of TRU, Sr, and Cs at INEEL (see Section 6, Problem Element 1.2.2.5).

5.4 University Program

One means of identifying and fostering technology development is the nation's universities. The TFA's strategy for working with universities is to leverage resources available through the FETC University Program. Specifically, TFA works with those universities that have environmental research and development programs that are recognized by and supported by DOE in advancing science, technology development, and industrial relationships.

There are two good examples of University Program support to the TFA:

- Mississippi State University's Diagnostic Instrumentation & Analysis Laboratory (DIAL) involvement in evaluating saltcake dissolution and concentrate re-precipitation phenomena (see Section 6, Problem Element 1.2.2.3).
- Florida International University's involvement in developing and demonstrating melter pour spout equipment improvements (see Section 6, Problem Element 1.2.3.2).

5.5 EM Science Program

Integrating science with programmatic technology assets is critical to the success of both TFA and EMSP. Acceleration of the technology development cycle through the integration of science can be achieved by maintaining multidisciplinary "technology fusion" teams that will deliver timely solutions to both short- and long-term environmental problems faced by DOE. The strategic intent of the TFA is to support strong programmatic and technical links between the EMSP, problem holders, and other EM programs.

The success of the EMSP depends on the utility and application of its results. The science program must have mechanisms through which new information and discoveries can be communicated to the users, so that this new information can be used to impact clean-up actions. The TFA will use numerous methods to foster communication such as annual workshops, special TFA seminars, and technical society symposia. Additionally, technical highlights and reports generated by TFA will be distributed to the relevant EMSP principal investigators.

The TFA has developed several work packages incorporating promising basic and applied research topical areas. Descriptions of the TFA's interest are located in several problem elements within Section 6.2. The listing of tanks-related EMSP projects is found within Appendix F.

5.6 Accelerated Site Technology Deployment Program

The ASTD Program is chartered with accelerating the implementation of previously demonstrated technologies or processes in EM clean-up activities. Accomplishing this mission requires DOE complex-wide cooperation and coordination in identifying, verifying, implementing, and subsequently deploying the technologies. In FY99, the Focus Areas were more fully incorporated into ASTD, acting as facilitators and integrators on ASTD projects. The TFA provides project coordination among all project participants, keeping its partners, sponsors, customers, and stakeholders aware of project progress and issues, and the potential for application at other sites.

An example of an ASTD Program activity within the TFA Program is the deployment of a modular evaporator system to reduce the volume of liquid waste generated by SRS's Consolidated Incinerator Facility (CIF).

Section 6 - Technical Program

6.1 Technical Program Summary

This section provides an overview of the technical program, including a brief discussion of assumptions and recommendations for a national science and technology program. In addition, this section summarizes TFA's technical strategies, planned accomplishments, and recommended program budget for addressing priority science and technology needs.

6.1.1 Program Overview

The TFA has continuously improved its program planning and development process since its inception in FY95, striving to meet and exceed the goals and strategies outlined in Section 4. In FY95, the TFA developed the organizational and technical basis for a nationally integrated technology program. During FY96, the TFA more fully developed an understanding of DOE complex-wide tank remediation issues. In FY97, the TFA established closer relationships with the users to improve the quality of the technical responses to site needs and to involve the users in program prioritization. This resulted in submission of a consensus-based FY99 Internal Review Budget and construction of a multiyear program plan and final FY98 program that was endorsed by the HLW Steering Committee (representing the sites' AMs) and approved by the Deputy Assistant Secretaries for Waste Management, Environmental Restoration, and Science and Technology. In FY98, TFA further refined the process to 1) ensure technical responses to site needs met user requirements and were prioritized with the users, 2) ensure the program definition integrated all TFA activities and resources including the core program, crosscutting programs, Industry Program, International Program, University Program, and ASTD into a single, Focus-Area centered program to respond to the highest priority tank waste remediation needs, and 3) confirm user commitment to use the results of science and technology investments to meet their needs. In FY99, the TFA continued to improve its program planning and development process leading to the FY01 Office of Science and Technology Corporate Review Budget (CRB) and the FY00 technology program outlined here.

This document represents the cumulative and fully integrated science and technology program required to meet the priority needs of the tank waste remediation system at the five DOE tank sites. Successful integration of all science and technology resources remains a challenge, and the TFA will continue to emphasize integration as the key element of the Focus Area-centered concept. Constantly changing budget priorities and site needs demand constant and significant management and technical attention. With the force of the entire TFA team behind efforts to implement the Focus Area-centered program, the next program development cycle should yield an even more responsive program for all EM tank investments.

6.1.2 Technical Program Structure

The general process flowsheet for tank waste remediation is depicted in Figure 6.1. Each step in the process is further defined using a problem element structure (listed below each process step in Figure 6.1), which identifies discrete technical requirements and activities within the generic flowsheet. Tank waste remediation science and technology needs received from the sites are categorized within this structure. This structure provides a compact, understandable, and process- and systems-oriented foundation for managing program development and execution. The FY99 Site Needs Assessment resulted in technical responses to each site need that were organized within the problem element structure (see the needs assessment at: http://www.pnl.gov/tfa/program/needs99/index.htm). These needs provided the basis for the multiyear program described in this document. The problem elements shown in bold in Figure 6.1 are those for which site needs were received and for which TFA has developed technical responses and corresponding budgets in FY00 and beyond.

6.1.3 Technical Strategies and Investments

This section summarizes the technical basis and strategies for FY00 and beyond for each process step and corresponding problem element depicted in Figure 6.1. More detailed descriptions of the technical needs, strategies, and technical activities are provided in Section 6.2. Table 6.1 provides a summary of the budget requests to address top priority needs for FY00 and FY01, and all priority needs for FY02 and beyond. The requested budget is $40.7M and $50.8M for FY00 and FY01, respectively. The FY02-FY04 budget requests assume unconstrained funding levels but are based on current FY99 site need submittals. As these outyears approach, TFA anticipates that new issues and problems will give rise to additional, high-priority site needs that cannot be predicted at this time. Therefore, work activities planned for FY01 and beyond may be delayed or rescoped depending on the actual budget level authorized and changing needs and priorities of the sites. Although the TFA-managed program includes activities to ensure integration of complex-wide needs, timely delivery of responsive technical solutions, and leveraging of all available resources to address the national tank remediation priorities, these activities and the budgets associated with them have not been included in this document. These activities include technical strategy development, technology delivery, and overall program management.

Safe Waste Storage

Investments in safe waste storage are needed to fill technical gaps, reduce costs, and avoid costly problems while ensuring protection of the public and environment. Priority site needs are focused on science and technology to 1) improve tank integrity monitoring and corrosion prevention, 2) improve tank ventilation, 3) improve waste characterization, and 4) reduce the volume of waste entering the tank farm through source and recycle stream waste reduction.

Problem Element 1.1.1 is to "Extend Tank Life." The TFA's near-term goal for avoiding tank corrosion is to improve upon methods for maintaining tank waste chemistry within site specifications by adapting commercial monitors for in-tank analysis of inhibitors and major species that control corrosion rate. The longer-term strategy for avoiding tank corrosion

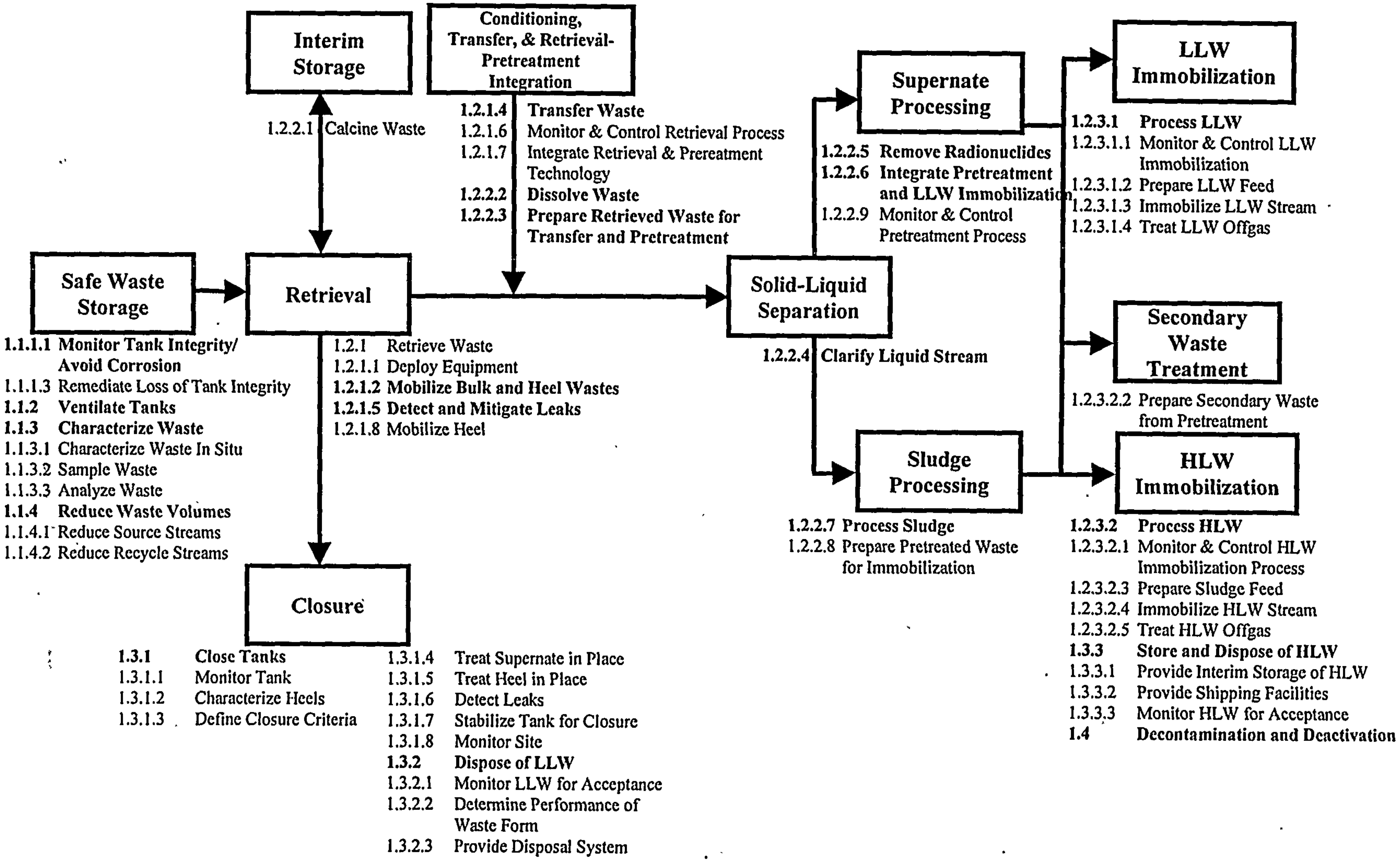


Figure 6.1. Generic Tank Remediation Flowsheet (Problem Elements in **Bold** indicate TFA has developed technical responses for site needs)

Table 6.1. Tanks Focus Area 5-Year Funding by Problem Element

Problem Element #	Problem Element Title	FY00	FY01	FY02	FY03	FY04	Total
1.1.1.1	Monitor Tank Integrity/Avoid Corrosion	2,050	2,285	1,850	1,550	1,550	9,285
1.1.2	Ventilate Tanks	780	580	555	400	400	2,715
1.1.3	Characterize Waste	3,465	4,580	2,830	2,500	2,500	15,875
1.1.4	Reduce Waste Volumes	1,820	2,145	5,200	8,850	7,300	25,315
1.2.1.2	Mobilize Bulk and Heel Wastes	6,827	10,125	9,600	4,625	4,625	35,802
1.2.1.4	Transfer Waste	1,325	2,100	2,175	4,950	4,950	15,500
1.2.1.5	Detect and Mitigate Leaks	300	300	1,500	1,500	1,500	5,100
1.2.2.2	Dissolve Waste	300	400	500	500	500	2,200
1.2.2.3	Prepare Retrieved Waste for Transfer and Pretreatment	2,350	2,895	1,900	1,200	1,200	9,545
1.2.2.4	Clarify Liquid Stream	150	200	800	850	800	2,800
1.2.2.5	Remove Radionuclides	9,810	8,410	8,050	6,250	6,000	38,520
1.2.2.6	Integrate Pretreatment and LLW Immobilization Technology Systems	300	300	300	300	300	1,500
1.2.2.7	Process Sludge	-	1,700	2,700	3,200	3,200	10,800
1.2.3.1	Process LLW	1,625	1,280	1,600	1,000	1,000	6,505
1.2.3.2	Process HLW	3,075	3,425	4,100	4,890	4,750	20,240
1.3.1	Close Tanks	2,335	2,600	4,900	7,500	7,500	24,835
1.3.2	Dispose of LLW	1,200	2,146	2,900	3,200	3,200	12,646
1.3.3	Store and Dispose HLW	-	400	3,000	3,800	3,800	11,000
1.4	Decontamination and Deactivation	3,000	4,950	4,650	4,300	4,300	21,200
Grand Total		40,712	50,821	59,110	61,365	59,375	271,383

Note: 1) Includes TFA core program funding, plus dedicated funding to TFA activities by other OST programs, including Cross Cut, Industry, International, and University Programs.

2) All funding estimates are for planning purposes only and are not official funding information. These estimates do not include any required management costs.

includes development and assessment of corrosion monitoring methods that provide more direct and real-time measurement of the corrosion potential within a tank than do corrosion coupons. The strategy for evaluating tank integrity also includes near- and longer-term approaches. Commercial NDE techniques will be evaluated and modified to support near-term deployments of an arm-based or crawler-based system to inspect tank walls. Longer-term efforts will integrate needs from multiple sites to define, develop, and test the specific systems needed to inspect tank floors, inspect surfaces below a liquid level, and assess a tank's integrity before reuse or waste retrieval. Specific technologies supported by the TFA to replace the baseline techniques include

- Develop an electrochemical noise corrosion monitor, deployed through a tank riser, for use at SRS and Hanford.
- Develop a Raman-based nitrate, nitrite, and hydroxide (NO_2^-/NO_3^-/OH^-) in-tank sensor for corrosion inhibitor concentration monitoring at SRS.
- Develop NDE methods for determining integrity of waste tanks, including end effectors to be deployed by an LDUA or crawler-based platform.
- Select and demonstrate camera systems for inspection of tanks.

Problem Element 1.1.2 is titled "Ventilate Tanks." The TFA's goal regarding this problem element is to reduce the cost of active ventilation. Specific activities include

- Select and demonstrate regenerable filter systems to replace HEPA filters within the existing active ventilation system. A commercial system will be procured for demonstration.
- Select and demonstrate commercial alternative filtration technology for high-temperature applications.

Problem Element 1.1.3 is titled "Characterize Waste." The TFA's goal regarding this problem element is to invest in tools and methods to characterize waste in situ to support sludge and supernate processing at Hanford, SRS, and ORR. Specifically, the TFA will

- Develop a sludge mapping system for ORR to determine the volumes of and interfaces between supernate, sludge, and/or hard heel.
- Develop and deploy a variable depth mobile fluidic sampler and at-tank analysis system into a Hanford waste tank to support feed staging for waste processing.
- Validate the LDUA sampler and nested, fixed-depth sampler for RCRA waste sampling at INEEL.
- Optimize and upgrade laser ablation/mass spectrometry (LA/MS) equipment and procedures for quantitative elemental analysis of solid samples.
- Conduct round robin tests on Tc-99 analytical procedures to reach consensus on preferred methodologies for Tc-99 analysis in tank wastes.

Problem Element 1.1.4 is titled "Reduce Waste Volumes." The TFA's goal regarding this problem element is to implement technologies to reduce source and recycle streams at SRS and INEEL. Specifically, the TFA will

- Assemble a treatment train of commercially available technologies to meet the waste acceptance criteria for SRS's liquid effluent treatment facility. Specifically, 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.
- Identify and evaluate methods for removing mercury and chlorides from INEEL waste streams such that they can be treated and disposed through less costly methods.
- Identify and evaluate opportunities for reducing waste generation from INEEL's decontamination facility, analytical laboratories, and filter leach facility.

For more information on these problem elements, see Section 6.2.

Retrieval

Investments in waste mobilization and retrieval fill technical gaps and reduce costs while ensuring safe operations. Priority site needs are focused on science and technology to 1) mobilize and retrieve bulk and heel wastes, including sludge and saltcake, and 2) detect and mitigate leaks during retrieval.

Problem Element 1.2.1.2 is titled "Mobilize Bulk and Heel Waste." The TFA's goals regarding this problem are to provide the following technologies and technical solutions:

- Pulsed air systems developed by industry (i.e., Pulsair®) to suspend solids before transfer at ORR Gunite and Associated Tanks (GAATs) (also part of waste conditioning for transfer).
- Jet pump eductor improvements to extend operating life in support of GAAT retrieval at ORR.
- Fluidic pulse-jet mixer systems developed and used in the United Kingdom (higher jet-velocity sluicing system) to suspend and transfer solids at ORR's Bethel Valley Evaporator Service Tanks (BVESTs).
- Low-volume density gradient techniques coupled with low flow rate pumps for bulk saltcake dissolution and removal without mixer pumps at Hanford and SRS.
- Enhanced sluicing systems, including enhanced nozzle and sweep designs for Hanford.
- Russian Pulsating Mixer Pump technology for slurry mobilization and transfer.
- Sludge mobilization and retrieval techniques for sludge heel retrieval at SRS and Hanford.
- Improved operation of baseline mixers at SRS.
- Flygt Mixers for waste mixing and mobilization to enhance bulk waste retrieval at SRS and Hanford.
- Variable-depth transfer pump to optimize waste retrieval from SRS and Hanford tanks.
- Chemical methods for heel removal and tank cleaning.
- Crawler based systems for heel removal.
- Identification and demonstration of commercial technologies for retrieving INEEL calcines from storage bins.

Problem Element 1.2.1.5 is titled "Detect and Mitigate Leaks." The TFA's goals relating to this problem are to provide retrieval methods that avoid leakage by controlling and minimizing water additions, provide leak detection devices that can rapidly output data to guide retrieval operations, and create strategies to mitigate leaks detected during retrieval. To address this goal, the TFA will

- Emphasize industry support and technology to develop methods for leak detection and mitigation.

For more information on these problem elements, see Section 6.2.

Conditioning, Transfer, and Retrieval-Pretreatment Integration
Retrieved wastes need to be transferred, and may require monitoring and physical and/or chemical conditioning to avoid problems with re-precipitation, solids formation, plugging of transfer lines, and settling, or simply to enhance downstream processing. Investments are needed for data and technologies to ensure the interface between retrieval and pretreatment avoids unwanted problems.

Problem Element 1.2.1.4 is "Transfer Waste." The TFA's goals relating to this problem are to deliver data and systems to reduce the risk during waste retrieval and waste transfers. Specific activities include

- Evaluate the impacts of physical and chemical conditions on waste rheology and transfer for Hanford, ORR, and SRS waste types.
- Identify and test pipeline plug-locating technologies.
- Adapt and test commercial systems for pipeline unplugging with side-by-side testing to evaluate the merits of a variety of systems. Functions and requirements, primarily from Hanford and SRS, will be used to select and test industry technologies acquired through a joint program between TFA and Industry Programs.
- Develop and deploy a waste conditioning compact processing unit (CPU) for monitoring and conditioning for safe transfer of GAAT waste to the Melton Valley Storage Tank (MVST).

Problem Element 1.2.2.3 is to "Prepare Retrieved Waste for Transfer and Pretreatment." The TFA's goal regarding this problem is to ensure retrieved wastes are ready for downstream processing. Specific activities include

- Evaluate saltcake dissolution and concentrate re-precipitation phenomena in complex solutions using nonradioactive surrogates to upgrade thermodynamic models support of retrieval and storage operations at Hanford for privatization.
- Study dilution, leaching, and washing of Hanford sludge, in conjunction with Problem Element 1.2.2.7, to provide information on the solubility of components in complex solid-liquid systems and identify the operating envelope required to minimize solids formation problems during pretreatment.

For more information on these problem elements; see Section 6.2.

Interim Storage
Interim storage includes those activities to enable storage of wastes as dry materials. Efforts are focused on calcination and dissolution of INEEL wastes.

Problem Element 1.2.2.2 is titled "Dissolve Waste." The TFA's goals are to provide data and technology to enable waste processing at INEEL. Specific activities include

- Evaluate the chemistry and dissolution behavior of existing calcine and bench-test preferred dissolution schemes to support flowsheet design decisions.

For more information on these problem elements, see Section 6.2.

Pretreatment
Investments in waste pretreatment must be fully integrated with waste retrieval, which provides feed to pretreatment, and waste immobilization, which receives feed from pretreatment processes. The pretreatment step is critical to reducing the volume of LLW and HLW products; this reduces disposal costs. Investments include clarifying liquid streams through solid-liquid separations, supernate processing to remove radionuclides, and sludge processing to remove excess chemical species that either increase the volume of HLW or adversely impact the performance of the HLW form. On Figure 6.1, pretreatment is shown as these three investments.

Problem Element 1.2.2.4 is titled "Clarify Liquid Streams." The TFA's goal regarding this activity is to deliver data and technologies to meet ORR, SRS, Hanford, and INEEL needs for process selection. Specific activities include

- Demonstrate operation of the cross-flow filtration system on MVST supernate.

Problem Element 1.2.2.5 is titled "Remove Radionuclides." This includes reducing the levels of Cs, Tc, Sr, or TRU to meet LLW disposal requirements onsite. The TFA's goal regarding radionuclide removal for alkaline wastes is to deliver improved Cs separations systems to reduce cost and technical risk at INEEL and SRS. Specific activities include

- Provide the necessary data to support SRS's evaluation of crystalline silicotitanate ion exchange and small-tank tetraphenylborate processes for Cs removal and to support design and implementation of the selected process.
- Deploy process monitor to detect and measure Cs in process effluents through the CMST.

The TFA's goal for TRU, Cs, and Sr removal from acidic wastes is to provide performance and engineering data to INEEL users on solvent-extraction and ion-exchange processes to confirm process assumptions, support a NEPA Record of Decision, and support Title 1 design. The TFA's goals are

- Demonstrate TRU and Sr solvent-extraction processes at INTEC with actual wastes.
- Develop an integrated Cs solvent-extraction process through the ESP Crosscutting Program for consideration as part of the INEEL flowsheet.

- Test alternative Cs and Sr separations processes through the ESP Crosscutting Program to provide additional performance data to support flowsheet development and downselects.

Problem Element 1.2.2.7 is titled "Process Sludge." The TFA's goal relating to this work is to provide Hanford with baseline processing data to support Phase II privatization. Specific activities include

- Evaluate chromium (Cr) removal performance during sludge washing and identify methods (e.g., oxidative leaching and caustic leaching) to improve Cr removal to ensure a baseline exists that can reduce the impact of Cr on HLW glass volume and subsequent immobilization costs.

For more information on these problem elements, see Section 6.2.

Waste Immobilization

Waste immobilization includes LLW immobilization, secondary waste treatment, and HLW immobilization. Efforts are focused on reducing cost and enhancing the baseline at SRS, as well as filling technical gaps in the baseline for Hanford and INEEL.

Problem Element 1.2.3.1 is titled "Process LLW." The TFA's goals regarding immobilizing LLW are to establish baseline processes for INEEL LAW immobilization and support Hanford and ORR privatization. Specific activities include

- Support INEEL with LAW stream pretreatment and immobilization development for the record of decision and Title 1 design for INEEL's unique waste streams.
- Develop grout formulations for INEEL's LAW.
- Evaluate alternative sorbents and stabilizers to improve the performance of waste forms for radioactive and hazardous wastes.

Problem Element 1.2.3.2 is titled "Process HLW." The TFA's goals regarding HLW processing are to reduce costs of HLW processes at SRS and to reduce the technical risks of HLW processing at INEEL and Hanford through process definition. Specific activities relating to this goal include

- 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 Cr, Tc, phosphate, halides, and actinides to optimize waste loading of these components.
- Establish glass compositions for INEEL's sodium-bearing and calcined wastes to avoid highly corrosive environments and produce acceptable waste forms.
- Test melters for use at INEEL to ensure compatibility of wastes and materials of construction.
- Develop and demonstrate equipment improvements, such as improved melter pour spout (Florida International University and Clemson University) and improved melter designs to accommodate noble metals deposits.
- Evaluate melter feed chemistry enhancements to optimize glass melting process.

Problem Element 1.3.2 is titled "Dispose of LLW." The TFA's goal for FY00 and beyond regarding LLW disposal is to ensure the availability of that data to support design of LLW disposal systems. Specific activities include

- Integrate efforts with the Hanford Vadose Zone/Groundwater project.
- Integrate with LLW disposal efforts.
- Integrate with ongoing and past science and technology investments (including Subsurface Contaminants Focus Area and EMSP) to define and prioritize specific technical issues to be addressed for improved performance assessment and design data to support Hanford.
- Provide technical data relating to glass composition and waste form durability to support product acceptance and performance assessment analyses.
- Determine the extent and impact of glass cracking in LLW glass packages for disposal.
- Examine natural analogues to provide insights regarding long-term surface barrier stability.
- Evaluate performance of capillary barriers after tank subsidence.

Problem Element 1.3.3 is titled "Store and Dispose HLW." The TFA's goals for FY00 and beyond regarding storage and disposal of HLW are to ensure the availability of methods and data to support the disposition of secondary wastes from HLW processing and to store and transfer HLW. Specific activities include

- Identify, demonstrate, and qualify alternative canister decontamination methods for application at WVDP and SRS.

Problem Element 1.4 is titled "Decontamination and Deactivation." The TFA's goals for this problem element focus on providing the remote tools necessary to operate efficiently in a radioactive environment, for maintenance, and for removal, size-reduction, and sorting of failed processing equipment. Specific activities include

- Provide remote technology to decontaminate and package long-length HLW tank equipment.
- Provide remote equipment for maintenance activities in process cells.
- Provide remote technology to enhance cleaning, decontamination, and reconfiguration of Hanford jumper pits.
- Demonstrate techniques for segregating/removing glass from failed melters.
- Demonstrate disassembly, decontamination, and size-reduction of ancillary canyon equipment.

For more information on these problem elements, see Section 6.2.

Closure

Tank closure activities include sampling or characterization of tank residuals, defining the closure criteria (i.e., answering the question "how clean is clean?"), and stabilizing the tank for closure.

Problem Element 1.3.1 is titled "Close Tanks." Investments in tank closure include advancements in grout formulations and delivery methods to improve performance for immobilizing residual tank waste and stabilizing SRS and ORR tanks. In addition, all aspects of tank isolation and stabilization for ORR and establishment of a basis for closure at Hanford and INEEL are required to reduce mortgages and move forward with retrieval and final tank closure decisions. The TFA's goal for FY00 and beyond regarding tank closure is to deliver the technologies and data to enable all five tank sites to proceed toward closure. Specific activities relating to this goal include

- Define tank closure acceptance criteria and technical bases for INEEL tanks.
- Develop and demonstrate grouting technology for tank closure.
- Demonstrate tank cleaning and heel treatment methods.
- Develop an improved understanding of Tc chemistry in tank heels and evaluate methods to remove Tc because of its significant contribution to dose in tank closure risk assessments.
- Evaluate technologies for sequestering radionuclide migration from tank closure and LLW disposal facilities.
- Test and deploy improved multipoint grout injection methods to accomplish grouting and closure of smaller tanks at ORR and SRS.
- Sample and retrieve wastes from ancillary equipment, such as a tank farm evaporator at SRS, to support closure of the remaining tanks and tank farms at SRS.

For more information on these problem elements, see Section 6.2.

6.2 TFA Problem Elements

The TFA problem elements are described on the following pages. Together, these problem elements form the core of the TFA program as depicted in Figure 6.1. Each problem element description includes the following sections: Title, Problem Element Description and Priority Site Needs, and Technical Tasks. The Problem Element Description and Priority Site Needs section includes a table with the site need number, the title of the need as submitted by the site, the Project Baseline Summary (PBS) number for each need, the title of the technical task addressing the need, and the OST technology number. (An index of OST technologies cited in this section is provided in Table 6.2.) In several instances, a need statement submitted by a site may include several needs that are addressed in several problem elements. Each technical task description includes a title, a brief summary of the need being addressed, and a list of key activities and schedule to resolve the need. For those activities funded in FY00, Budget Profiles are provided that show the associated Technical Task Plan (TTP) numbers and budgets. In a few instances, it was not possible to clearly identify the funding split when a particular TTP task spanned two or more problem elements.

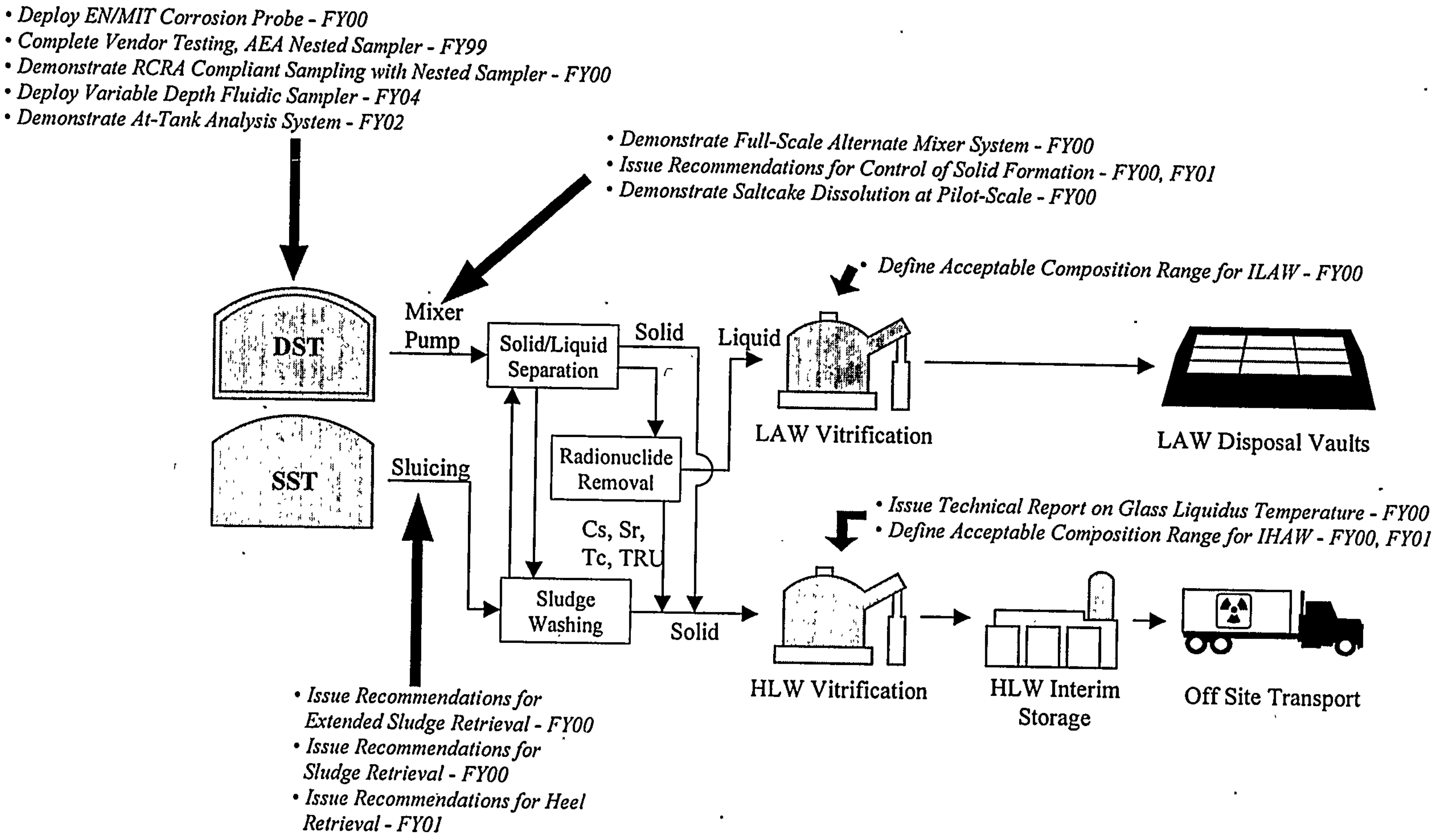
All funding totals are shown as $ x 1,000.

Figures 6.2 through 6.6 show the path to closure for the Hanford, INEEL, ORR, SRS, and WVDP. For each site, key TFA activities supporting the path to closure are identified.

Table 6.2. Index of OST Technologies

OST #	Technology Title
10	Alternative Landfill Cover (SCFA)
20	Out of Tank Evaporator
21	Cesium Removal Using Crystalline Silicotitanate
22	SRS Tank Closure
82	Low Activity Waste Forms
85	Light Duty Utility Arm
127	Laser Ablation/Mass Spectroscopy (LA/MS)
130	Topographical Mapping System (TMS)/Laser Range Finder (LRF)
233	Sludge Washing
279	Automated Monitoring System for Fluid Level and Density in High-Level Waste Tanks (CMST)
347	TRUEX/SREX
350	Crossflow Filtration
410	Cobalt Dicarbollide Development (U.S.) (ESP)
523	Barriers and Post-Closing Monitoring (SCFA)
810	LDUA - Supervisory Data Acquistion and Supervisory Control System
812	Confined Sluicing End Effector
841	Russian Separations - Cobalt Dicarbollide (ESP)
860	Grab Sampler End-Effector
881	Calcine Dissolution
890	Stereo Viewing Systems
1510	Pulsed-Air Mixer
1511	AEA Fluidic Pulse Jet Mixer
1547	Comparative Testing of Pipeline Slurry Monitors (CMST)
1985	Corrosion Probe
1989	Saltcake Dissolution
1996	Non-destructive Examination End-Effector
2009	High Activity Waste Forms and Processes
2011	In-Tank Waste Retrieval - Arm Based System
2012	In-Tank Waste Retrieval - Vehicle Based System
2015	Integrated Raman pOH Sensor for In-Tank Corrosion Monitoring (CMST)
2087	Remote Maintenance Design for Tank Waste Compact Processing Units (Robotics)
2091	Metal Filters for Waste Tank Ventilation
2092	DWPF Melter Pouring Enhancements
2094	Product Acceptance Testing
2096	Pretreatment Process Analysis Tool
2097	Heel Retrieval for SRS
2115	Retrieval Analysis Tool
2117	Enhanced Sluicing
2118	Vadose Zone Characterization System
2119	Nested Fixed Depth Fluidic Sampler
2181	Equipment Pit D&D System (Robotics)
2195	Tank Riser Pit Decontamination System (Robotics)
2232	Flygt Mixer
2235	At-Tank Sampling for High-Level Waste (CMST)
2236	Sludge Wash Monitor (CMST)
2366	Disposable Crawler
2367	Pipe Unplugging
2368	Multipoint Grout Injection
2370	Russian Retrieval Technologies
2371	Thermal Denitration
2383	Vitrification Expended Material Processing System

Figure 6.2. Hanford Path to Closure



- *Deploy EN/MIT Corrosion Probe - FY00*
- *Complete Vendor Testing, AEA Nested Sampler - FY99*
- *Demonstrate RCRA Compliant Sampling with Nested Sampler - FY00*
- *Deploy Variable Depth Fluidic Sampler - FY04*
- *Demonstrate At-Tank Analysis System - FY02*

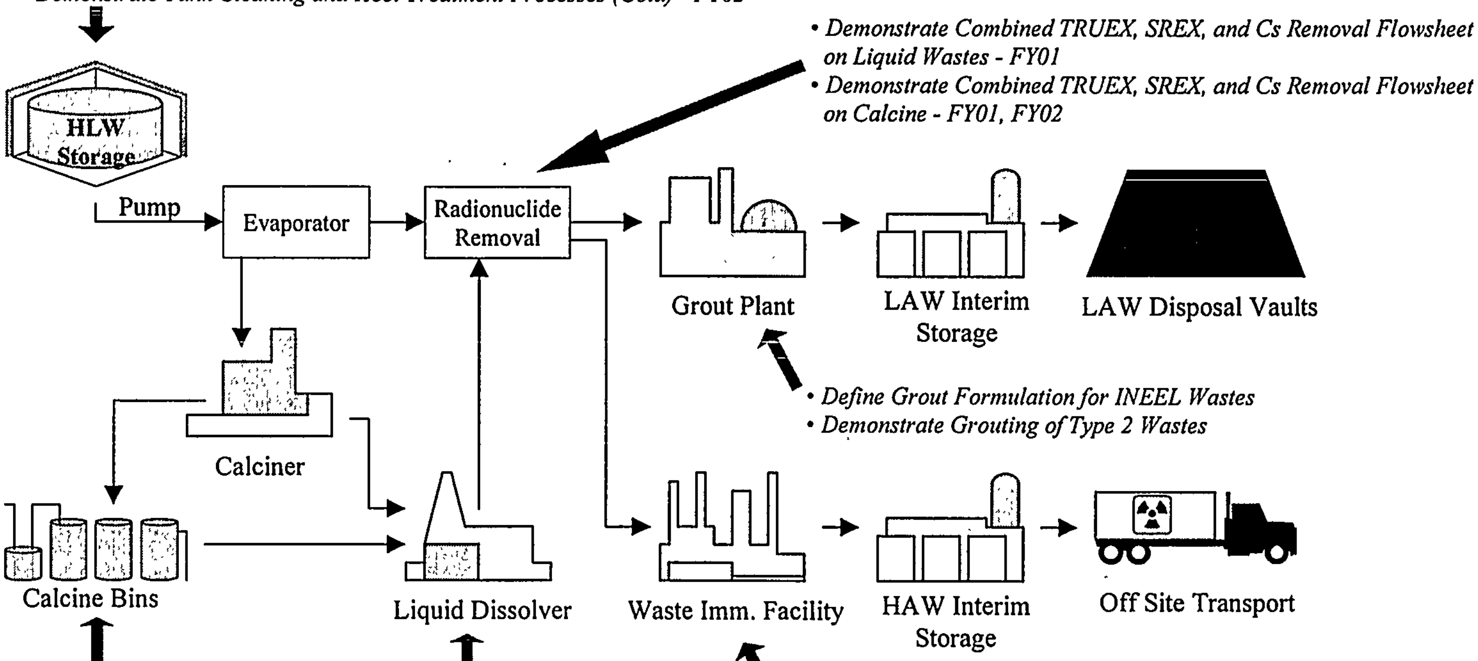
- *Demonstrate Full-Scale Alternate Mixer System - FY00*
- *Issue Recommendations for Control of Solid Formation - FY00, FY01*
- *Demonstrate Saltcake Dissolution at Pilot-Scale - FY00*

- *Define Acceptable Composition Range for ILAW - FY00*

- *Issue Technical Report on Glass Liquidus Temperature - FY00*
- *Define Acceptable Composition Range for IHAW - FY00, FY01*

- *Issue Recommendations for Extended Sludge Retrieval - FY00*
- *Issue Recommendations for Sludge Retrieval - FY00*
- *Issue Recommendations for Heel Retrieval - FY01*

Figure 6.3. Idaho National Engineering and Environmental Laboratory Path to Closure



- *Demonstrate Equivalency of LDUA End Effector for RCRA Compliant Sampling - FY00*
- *Deploy Nested, Fixed Depth Sampler in INTEC Waste Tank - FY03*
- *Develop Tank Closure Criteria and Plan - FY00*
- *Define Grout Formulation for Tank Closure*
- *Demonstrate Tank Cleaning and Heel Treatment Processes (Cold) - FY02*

- *Demonstrate Combined TRUEX, SREX, and Cs Removal Flowsheet on Liquid Wastes - FY01*
- *Demonstrate Combined TRUEX, SREX, and Cs Removal Flowsheet on Calcine - FY01, FY02*

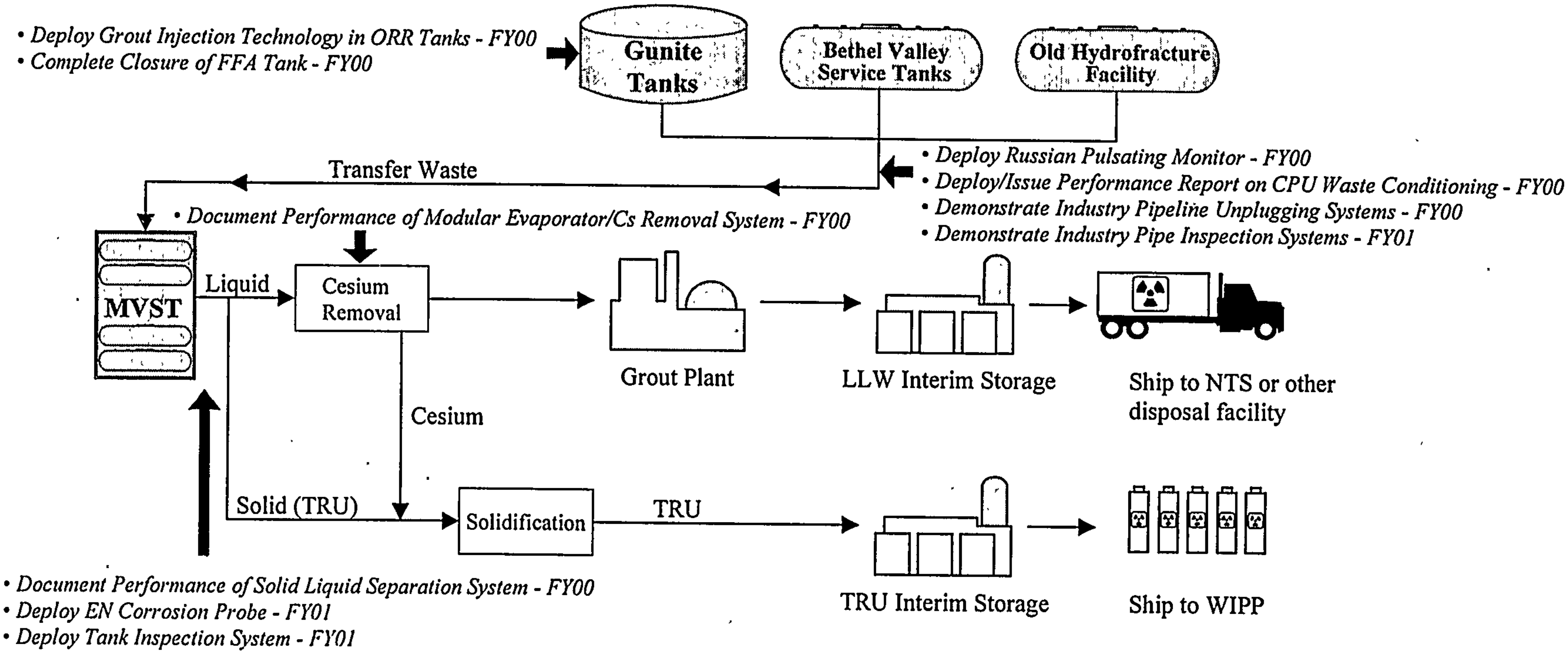
- *Define Grout Formulation for INEEL Wastes*
- *Demonstrate Grouting of Type 2 Wastes*

- *Install Risers on Bin Set 1*
- *Deploy Calcine Sampling System - FY02*

- *Demonstrate Lab-scale Dissolution of Calcine - FY00*

- *Issue Summary Glass Formulation Report - FY00*
- *Recommend Melter Technology for HAW - FY00*
- *Define Key Melter Parameters for HAW - FY01*
- *Demonstrate INEEL HAW Immobilization at Pilot-Scale - FY01*

Figure 6.4. Oak Ridge Reservation Path to Closure



- *Deploy Grout Injection Technology in ORR Tanks - FY00*
- *Complete Closure of FFA Tank - FY00*

- *Deploy Russian Pulsating Monitor - FY00*
- *Deploy/Issue Performance Report on CPU Waste Conditioning - FY00*
- *Demonstrate Industry Pipeline Unplugging Systems - FY00*
- *Demonstrate Industry Pipe Inspection Systems - FY01*

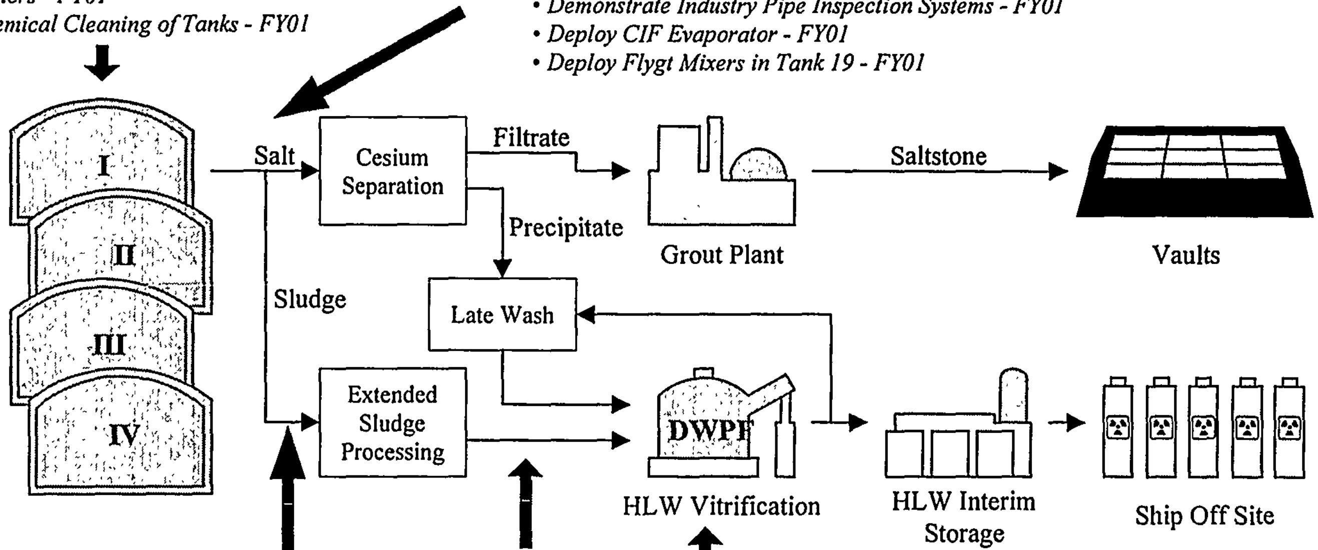
- *Document Performance of Modular Evaporator/Cs Removal System - FY00*

- *Document Performance of Solid Liquid Separation System - FY00*
- *Deploy EN Corrosion Probe - FY01*
- *Deploy Tank Inspection System - FY01*

Figure 6.5. Savannah River Site Path to Closure

- *Demonstrate CIF Evaporator - FY00*
- *Deploy Corrosion Species and EN Probes - FY00*
- *Demonstrate Metal Filters - FY01*
- *Issue Russian Chemical Cleaning Recommendations - FY00*
- *Deploy Grout Injection/CloseOBG Solvent Extraction Tank - FY00*
- *Deploy Metal Filters - FY01*
- *Demonstrate Chemical Cleaning of Tanks - FY01*

- *Document Data to Support Selection and Design of Salt Disposition Alternative - FY00 - FY02*
- *Deploy Tank 19 Heel Retrieval System - FY00*
- *Install CIF Evaporator - FY00*
- *Issue Requirements/Specification for Type I/II Tanks Retrieval - FY00*
- *Demonstrate Full-Scale Alternate Mixer System - FY00*
- *Demonstrate Industry Pipeline Unplugging Systems - FY00*
- *Deploy Retrieval System in Type I/II Tank - FY02*
- *Issue Recommendations for Mixer Pump Improvements - FY01*
- *Issue Recommendations for Transfer/Pipeline Unplugging - FY01*
- *Demonstrate Industry Pipe Inspection Systems - FY01*
- *Deploy CIF Evaporator - FY01*
- *Deploy Flygt Mixers in Tank 19 - FY01*

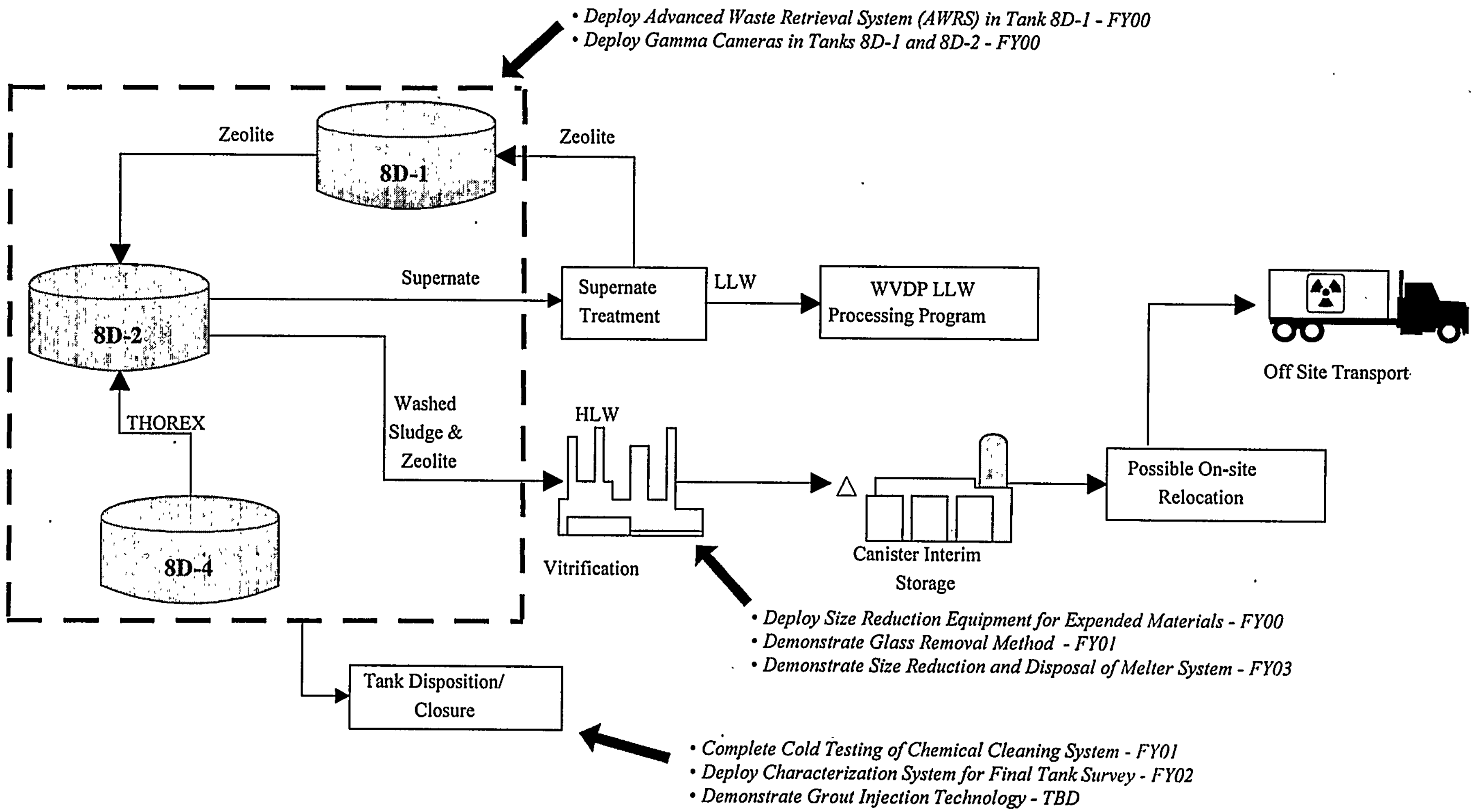


- *Deploy Optimized Waste Loading in DWPF - FY01*

- *Issue Recommendations for Extended Sludge Retrieval - FY99*

- *Recommend Design for DWPF Melter Pour Spout/Riser Heaters - FY00*
- *Recommend Design Requirements for Next Generation Melter - FY01*
- *Demonstrate Glass Removal from Failed Melter - FY01*
- *Demonstrate Size Reduction and Disposal of Melter System - FY03*

Figure 6.6. West Valley Demonstration Project Path to Closure



- *Deploy Advanced Waste Retrieval System (AWRS) in Tank 8D-1 - FY00*
- *Deploy Gamma Cameras in Tanks 8D-1 and 8D-2 - FY00*

- *Deploy Size Reduction Equipment for Expended Materials - FY00*
- *Demonstrate Glass Removal Method - FY01*
- *Demonstrate Size Reduction and Disposal of Melter System - FY03*

- *Complete Cold Testing of Chemical Cleaning System - FY01*
- *Deploy Characterization System for Final Tank Survey - FY02*
- *Demonstrate Grout Injection Technology - TBD*

Problem Element Title: 1.1.1.1 Monitor Tank Integrity/Avoid Corrosion

Problem Element Description and Priority Site Needs

Tank integrity and corrosion avoidance are critical issues during both long-term storage and retrieval of radioactive tank wastes. Real-time corrosion inhibitor and corrosion monitoring methods are needed to provide early detection of potential problems that may lead to leakage or structural failure. There is a need to perform nondestructive examination (NDE) of tank walls to determine structural integrity. Current methods are limited to contact examinations and usually require a cleaned surface and coupling between the inspection device and structure being inspected. This problem element addresses methods to avoid corrosion of steel tanks and monitor the integrity of tanks to aid in early detection of tank problems that may lead to leakage, to minimize the potential for tank failure, and to reduce the costs of maintaining safe operating conditions. The site needs addressed in this problem element are identified below.

Problem Element: 1.1.1.1 Monitor Tank Integrity/Avoid Corrosion

STCG Need Number	Need Title	PBS Number	Technical Task	OST Number
RL-WT04	DST Corrosion Monitoring	RL-TW03	EN Corrosion Probe	1985, 2015
SR99-2045	In-Tank Corrosion Probe Development	SR-ER02, SR-HL01, SR-HL03	EN Corrosion Probe	1985, 2015
OR-TK-01	ORNL Tank Waste Characterization (Corrosion Monitor)	OR-311	EN Corrosion Probe	85, 130, 860, 890, 1985, 1996, 2015
RL-WT05	Remote Inspection of HLW Single-Shell Tanks	RL-TW03	Nondestructive Examination of Tanks	85, 130, 860, 890, 1996
RL-WT022	Tank Knuckle NDE	RL-TW03	Nondestructive Examination of Tanks	85, 130, 860, 890, 1996
SR99-2035	Develop Advanced Techniques for Life Extension of Tanks/Piping	SR-HL01, SR-HL02, SR-HL04	Nondestructive Examination of Tanks	85, 130, 860, 890, 1996
OR-TK-01	ORNL Tank Waste Characterization (Structural Integrity)	OR-311	Nondestructive Examination of Tanks	85, 130, 860, 890, 1985, 1996, 2015
ID-2.1.20	Tank Annulus/Vault Inspection	ID-HLW-103	Nondestructive Examination of Tanks	85, 130, 860, 890, 1996

Technical Tasks

Electrochemical Noise (EN) Corrosion Probe (TFA Technical Response 99043; Work Package WT-04-01)

ORR, SRS, and Hanford Site need improved real-time corrosion detection systems that can "fine tune" the amount of inhibitor needed and provide more rapid and less expensive methods to detect the corrosive characteristics of tank wastes. A corrosion probe system that provides a real-time indication of corrosion potential in HLW tanks at multiple levels or positions in the tank is needed to reduce the costs of chemical analysis and detection while providing data on tank conditions.

The electrochemical noise (EN) probe is being developed as a corrosion-monitoring tool for HLW tanks. This technique can provide real-time, on-line measurements of the corrosion processes in the tank, including the most probable processes of pitting and stress corrosion cracking. Development of the EN probe was initiated at Hanford and is being adapted for SRS. Future development of a stainless steel probe for application at ORR is anticipated. By the end of FY99, a newly designed EN probe based on the multi-function instrument tree approach will be installed in a Hanford waste tank. Data from the currently installed probes is being analyzed to validate the EN corrosion probe as an alternative for monitoring HLW tank corrosion. At SRS, a combined EN corrosion probe/Raman corrosion species monitor (see below) will be fabricated for deployment in FY00.

Workscope to complete this task includes:

- Design and deploy fourth version of the EN probe, including improved seal and improved data collection and analysis capabilities (FY00, Hanford).
- Deploy combined EN corrosion species probe at SRS (FY00, SRS).
- Install integrated corrosion probe monitoring station (FY01, Hanford)
- Document final EN corrosion probe design (FY01, Hanford).
- Design stainless steel EN corrosion probe for application at ORR (FY00, Hanford, ORR).
- Deploy stainless steel EN corrosion probe (FY01, ORR).

Budget Profile: EN Corrosion Probe
(TFA Technical Response 99043; Work Package WT-04-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL09WT41	270	270			
INEEL						
ORR	OR10WT21	95	170			
SRS	SR09WT41	80	20			
WVDP						
TFA Total		445	460	TBD	TBD	TBD

<u>Corrosion Species Monitor (Ion-Species Raman Probe)</u> (TFA Technical Response 99043; Work Package WT-04-01)
High-level liquid wastes at the SRS and Hanford are stored in carbon-steel tanks that are susceptible to nitrate ion-induced corrosion cracking. Monitoring and maintaining adequate nitrate, nitrite, and hydroxide ion levels prevents this degradation. Sensors that could monitor all three species would be optimal to reduce the costs of current baseline sampling and laboratory analysis methods, and to minimize the addition of corrosion inhibitor solution. Currently, inhibitor 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 an $OH^-/NO_3^-/NO_2^-$ monitor could be used to control the addition of inhibitor solution.

A corrosion species monitor is being developed by the Characterization, Monitoring, and Sensor Technology Crosscutting Program (CMST) as a technique for real-time, on-line monitoring of waste chemistry. A robust, in situ probe that uses Raman spectroscopy for analysis is capable of measuring the nitrite/nitrate concentration and the hydroxide concentration. EIC Laboratories are developing the probe. The corrosion species monitor will be combined with an EN corrosion probe (see above) for deployment at SRS. Workscope to complete this task includes:

- Deploy probe at SRS (FY00, SRS).
- Complete cold demonstration of EIC corrosion species monitor (FY00, SRS).
- Document performance of combined EN/corrosion species probe (FY00, SRS).
- The EM Science Program is funding several projects related to tank corrosion. The TFA is interested in continuing relevant work through the science program.

Budget Profile: Corrosion Species Monitor
(TFA Technical Response 99043; Work Package WT-04-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL						
ORR						
SRS	SR09WT41	145				
WVDP						
TFA Total		145	75	TBD	TBD	TBD
ASTD						
CMST	NV08C231	65				
FETC						
ESP						
International						
Robotics						
University						
EM-50 Total		210	75	TBD	TBD	TBD

Nondestructive Examination (NDE) of Tanks (TFA Technical Response 99075; Work Package WT-03-01)
The need to perform NDE of tank walls and/or floors supports structural integrity determinations, tank life expectancy estimations, and retrieval strategy development. Current methods are limited to contact examinations and usually require a cleaned surface and coupling between the inspection device and structure being inspected. This is very difficult in underground storage tanks. Improved methods allowing inspections to be performed without direct contact or through liquids are needed. The knuckle region of tanks (where the 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 the

quantitative data on tank structure that is needed to ensure safety of current tank configurations and evaluate side loading limits. Hanford specifically needs an NDE system for both SSTs and DSTs to support sluicing feasibility assessments and life-expectancy estimation. Systems that can be deployed using a remote device, such as the Light-Duty Utility Arm (LDUA) or other similar robotic equipment are desired. At SRS, visual and NDE inspection methods are needed to inspect tank walls and the annular space of these tanks to validate their integrity for longer-term waste storage. At ORR, routine structural integrity verification is needed before returning tanks to long-term service. At INEEL, a spare tank must be inspected as part of a certification effort to meet RCRA requirements for storage of newly generated liquid waste. Typical of all applications is the constraint of limited access into the tanks to conduct the inspections. A deployment device is therefore also needed. Also, some applications require inspecting the tanks below the level of the waste.

In FY99, INEEL used the LDUA to deploy a NDE end effector to demonstrate its applicability to inspect tank welds. The equipment was to perform tank inspection using NDE and stereo video camera end effectors.

Tandem Synthetic Aperture Focusing Technique, or T-SAFT, an ultrasonic NDE technology, has been demonstrated in the laboratory to provide information on through-wall crack size and will be adapted for inspection of the small-radius tank knuckle region.

Industry, DOE laboratories, universities, and the Center for Non-Destructive Evaluation (CNDE) are sources for technologies that will be evaluated and deployed at the sites to inspect tanks and assess their integrity. Work activities to support the needs for tank integrity assessments will include:

<u>NDE</u>

- Identify remote inspection technologies and deployment methods for each site (FY00, SRS, INEEL, Hanford, CMST, Robotics).
  - Survey technologies available from the DOE complex, industry, and foreign companies.
  - Develop specifications and selection criteria.
  - Evaluate candidate technologies.
- Obtain/procure NDE and deployment technologies for each site (FY01, SRS, INEEL, Hanford).
  - Prepare performance specifications.
  - Perform acceptance testing after vendor fabrication.
  - Deliver, cold test, and perform site qualification.
- Deploy NDE and deployment technologies (FY01-FY02, SRS, INEEL, Hanford).

<u>T-SAFT</u>

- Modify T-SAFT code to support application to tank knuckle region (FY00, Hanford).
- Deploy T-SAFT technology to examine Hanford DST knuckle region (FY01, Hanford).

Problem Element Title: 1.1.1.1 Monitor Tank Integrity/Avoid Corrosion

Budget Profile: Non-Destructive Examination (NDE) of Tanks (TFA Technical Response 99075; Work Package WT-03-01)						
	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL00WT23 RL30WT21	65 75				
INEEL	ID70WT22	75				
ORR	OR10WT21	210*				
SRS	SR18WT21	70				
WVDP						
TFA Total		495	850	1650	TBD	TBD
ASTD						
CMST	CH10C211	300	300	200		
FETC	FT06IP01	400	400			
ESP						
International						
Robotics		200	200			
University						
EM-50 Total		1395	1750	1850	TBD	TBD

*Note: ORR has informed the TFA that it now does not plan to use the NDE technology. Because this information became available just before MYPP publication, changes to the MYPP were not made.

Problem Element Description and Priority Site Needs

Waste tank ventilation is necessary to maintain safe operating conditions within the tank farm. Ventilation systems and gaseous effluent treatment systems prevent exposure of workers to highly radioactive aerosols and particulate that are generated within the waste tanks during waste decay, mixing, and transfer. Methods for active and passive waste tank ventilation and gas filtration are encompassed within this problem element. The site needs addressed in this problem element are addressed below.

Problem Element: 1.1.2 Ventilate Tanks				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
ID-2.1.27	Blowback Metal Filters for Solids (calcine) Retrieval	ID-HLW-103	Alternative Air Filtration Technology	2091
SR99-2027	Demonstrate Alternative Filtration Technologies to Replace HEPA Filters	SR-HL01, SR-HL02	Alternative Air Filtration Technology	2091

Technical Tasks

Alternative Air Filtration Technology (TFA Technical Response 99071; Work Package WT-04-01)

Throughout the DOE complex, HEPA filters are used to ensure that air emissions are free of radioactive particulates from tanks and waste processing operations. The HEPA filters must be replaced when excessive material collects on the filter, causing higher pressure drop and/or dose, or when the filter fails, typically because of wetting of the filter media. During filter replacement, personnel are exposed to radiation. The used filters must then be disposed, an added cost. Washable and recyclable HEPA filters will reduce personnel exposure and will reduce the costs for processing and disposal of the filters.

SRS has a specific need for washable HEPA filter technology to increase the life of HLW tank HEPA filters and to reduce the volume of solid waste associated with the spent filters. At INEEL, the need is for a regenerable filter system to replace the current HEPA filters used as the final element of an air treatment system used for pneumatic transport of HLW calcine.

Laboratory testing has provided proof-of-concept that two different commercially available stainless steel filter technologies can be cleaned in-place using a liquid spray system. In FY99, FETC established contracts with two commercial firms (MOTT Corporation and Ceremem Corporation) to develop conceptual designs for regenerable HEPA filter systems. In parallel with the design effort, the proposed ceramic and metal filter media are being tested. Further development and deployment will depend on the design effort and filter testing. Workscope to complete this task includes:

SRS Regenerable HEPA Filter System for Tanks

- Complete design and construction of regenerable HEPA filter system for SRS tank application (FY00, FETC).
- Conduct cold demonstration of regenerable HEPA filter system for SRS tank application (FY01, SRS).

- Deploy regenerable HEPA filter system on SRS tank (FY01, SRS).

<u>INEEL Regenerable HEPA Filter System for Calcine Transport</u>

- Prepare Functions and Requirements for regenerable HEPA filter system for INEEL calcine transport application (FY00, INEEL).
- Procure regenerable HEPA filter system for INEEL calcine transport (FY02 FETC).
- Deploy regenerable HEPA filter system for INEEL calcine transport (FY06 INEEL).

Budget Profile: Alternative Air Filtration Technology
(TFA Technical Response 99071; Work Package WT-04-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL	ID70WT22	60				
ORR						
SRS	SR18WT21	420				
WVDP						
TFA Total		480	580	155	TBD	TBD
ASTD						
CMST						
FETC	FT06IP01	300	0	400		
ESP						
International						
Robotics						
University						
EM-50 Total		780	580	555	TBD	TBD

Problem Element Description and Priority Site Needs

The baseline method for characterization of tank wastes is to collect waste samples and perform laboratory analyses in a hot cell. Improvements in sample collection methods, hot cell analytical methods, and in situ characterization methods are needed to expedite and reduce the costs of tank waste characterization. In situ characterization and at-tank sampling and characterization are highly desired as each could provide more rapid and cost-effective waste analysis. Characterizing the waste's physical, chemical, and radiochemical properties is required for planning and implementing tank safety, retrieval, pretreatment, immobilization, and closure processes. The site needs addressed in this problem element are identified below.

Problem Element: 1.1.3 Characterize Waste

STCG Need Number	Need Title	PBS Number	Technical Task	OST Number
RL-WT09	Representative Sampling and Associated Analysis to Support Operations and Disposal	RL-TW01 RL-WT05	Waste Sampling and At-Tank Analysis	2119, 2235
ID-2.1-26	Nested Array Fluidic Sampler for Tank Solution Characterization	ID-HLW-101	Waste Sampling and At-Tank Analysis	85, 860, 2119
ID-2.1.43	Certify LDUA Sampler as EPA-Approved Method of Sampling Tank Heel Liquids	ID-HLW-103	Waste Sampling and At-Tank Analysis	85, 860
ID-2.1.44	Certify LDUA Sampler as EPA-Approved Method of Sampling Tank Heel Solids	ID-HLW-103	Waste Sampling and At-Tank Analysis	85, 860
SR99-2037	Tank Heel Removal/Closure Technology – Waste Characterization	SR-HL01, SR-HL02, SR-HL03	Slurry Transfer and Tank Waste Mixing Monitors	279, 1547, 2236
SR99-2044	Demonstrate In-situ Characterization Weight Percent Probe	SR-HL01, SR-HL02, SR-HL03	Slurry Transfer and Tank Waste Mixing Monitors	279, 1547, 2236
OR-TK-04	ORNL Sludge Mixing and Slurry Transport	OR-321, OR-322	Slurry Transfer and Tank Waste Mixing Monitors	279, 1547, 2236
RL-WT01	Tc-99 Analysis in Hanford Tank Waste and Contaminated Tank Farm Areas	RL-TW01	Validate Analytical Procedures for Rad Waste Samples	127
SR99-2051	Technology to Mitigate Effects of Technetium under Tank Closure Conditions	SR-HL03	Validate Analytical Procedures for Rad Waste Samples	TBD
RL-WT065	Direct Inorganic and Organic Analyses of High Level Waste	RL-TW05	Validate Analytical Procedures for Rad Waste Samples	127
ID-2.1.16	Decon Facility/Analytical Facility Waste Reduction	ID-HLW-01	Validate Analytical Procedures for Rad Waste Samples	127
OH-WV-906	Radioactivity Measurement of High-Level Waste Tank Residual		Waste Sampling and At-tank Analysis	
OR-TK-01	ORNL Tank Waste Characterization (Sludge Mapping)		In Situ Characterization	130, 1996

Technical Tasks

<u>Waste Sampling and At-Tank Analysis</u> (TFA Technical Response 99046; Work Package WT-01-01)
A sampling system capable of obtaining representative waste samples is needed to support ex-situ waste characterization at Hanford and INEEL. The sampler should work with non-homogeneous wastes, rapidly obtaining samples at multiple heights and during tank mixer operation. The sampler should be capable of taking RCRA-compliant samples of the waste. Hanford also has a need for an at-tank analysis system to facilitate rapid chemical analyses for feed staging and process control. INEEL also has a need to obtain EPA equivalency certification for a sampling end effector for the LDUA.

AEA Technology has developed a fixed-depth fluidic sampler that has been successfully deployed at SRS. A nested-array, multi-point, fixed-depth sampler based on this single-sample point design will be developed for sampling wastes at Hanford and INEEL. The feasibility of the nested, fixed depth sampler for non-RCRA applications was demonstrated in FY99. Workscope to complete this task includes

- Complete feasibility demonstration of RCRA-compliant sampler configuration of the nested, fixed-depth sampler (FY00, AEAT).
- Complete detailed design package for nested, fixed depth sampler (FY00, AEAT, Hanford, INEEL, Robotics).
- Complete fabrication of nested, fixed depth samplers for INEEL and Hanford (FY01, AEAT).
- Complete cold acceptance tests of nested, fixed depth sampler for INEEL (FY02, INEEL, Hanford, Robotics, AEAT).
- Complete cold acceptance tests of integrated nested, fixed depth sampler and at-tank analysis system (see below) for Hanford (FY03, Hanford, INEEL, Robotics, CMST, AEAT).
- Deploy nested, fixed depth samplers at Hanford and INEEL (FY04, EM-30 funded).

At Hanford, an at-tank analysis system is to be used with the nested, fixed depth sampler for rapid waste feed characterization to support waste transfer operations. Analyses of interest include weight percent particulates, particle size distribution, cesium-137 and sodium concentration, and nitrate-to-nitrite ion ratio. Selection of a commercial firm to design and construct the at-tank analysis system was initiated in FY99. Workscope to complete this task includes

- Complete final design specification for at-tank analysis system (FY00, CMST, Industry).
- Complete proof-of-principle testing, detailed design and fabrication of at-tank analysis system(FY01, CMST, Industry, Hanford).
- Complete cold acceptance tests of integrated nested, fixed depth sampler (see above) and at-tank analysis system (FY03, Hanford, INEEL, Robotics, CMST, AEAT).
- Deploy integrated nested, fixed depth sampler and at-tank analysis system at Hanford (FY04, EM-30 funded).

To sample tank heels, INEEL will use a sampler end effector on the light-duty utility arm. The heel is sampled by drawing the waste into an evacuated sample chamber. INEEL needs to demonstrate that this sampling method is equivalent to grab sampling with zero headspace in order to request an EPA waiver to use the LDUA sampler in place of grab sampling. Workscope to complete this task includes

- Document testing to demonstrate equivalency of LDUA sampler and grab sampling (FY00, INEEL).

At WVDP, a sampling end-effector for their mast-mounted tool delivery system is needed for sampling tank heels. Workscope to complete this task includes:

- Complete design fabrication, and testing of prototype sampling tool end effector for Tool Deployment System (FY00, WVDP, Robotics, TFA).

Budget Profile: Waste Sampling and At-Tank Analysis
(TFA Technical Response 99046; Work Package WT-01-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL08WT22	340				
INEEL	ID77WT22	350				
ORR						
SRS						
WVDP	OH00WT22	25				
TFA Total		715	200	330	TBD	TBD
ASTD						
CMST	FY09C211	600	600	400		
FETC			400	400		
ESP						
International	AEAT	1300	1190	400		
Robotics	RL37C131	150	150	150		
	OR17C131	200				
University						
EM-50 Total		2965	2540	1680	TBD	TBD

<u>Slurry Transfer and Tank Waste Mixing Monitors</u> (TFA Technical Response 99078; Work Package WT-08-01)
The physical and chemical properties of tank waste must meet operational requirement for retrieval and pretreatment operations to be successful. Particle size, weight percent solids, and chemistry changes occurring during retrieval impact the efficiency of downstream pretreatment operations. At Hanford, ORNL, and SRS, transfer line pluggage is an operational concern. In-tank and pipeline monitors are needed to measure slurry density, viscosity, solids content, particle size distribution, and flow rate before and during retrieval and transport of wastes to guard against transport line plugging. Real-time rheological property data is needed at SRS to support deployment of waste mixing equipment.

To address these needs, the TFA and CMST are evaluating slurry monitors and rheological property instrumentation. Hot field tests of in-line slurry monitors (i.e., an Endress + Hauser coriolis flow/density monitor, an Argonne National Laboratory (ANL) ultrasonic weight percent solids monitor, and a Lasentec particle size distribution monitor) are being conducted at ORNL in FY99. A dual coriolis monitor system will be developed to measure weight percent solids in tank slurries. Rheology instrumentation and a slurry monitor to predict pipeline plugging will be evaluated for deployment. Workscope to complete this task includes

- Design and fabricate dual coriolis weight percent solids monitor (FY00, CMST, University Program).
- Complete cold demonstration of dual coriolis weight percent solids monitor (FY00, ORNL, SRS, CMST, University Program).
- Deploy dual coriolis weight percent solids monitor at SRS and ORR (FY01, SRS, ORNL, CMST).
- Conduct vendor survey to locate commercial rheology measurement instrument to monitor tank mixing (FY00, SRS).
- Deploy rheology measurement system (FY00, SRS).
- Evaluate instrumentation to predict pipeline plugging (FY01, CMST, ORNL, SRS).
- Deploy slurry monitor to predict pipeline plugging (FY02, CMST, SRS).
- Continue development of promising EMSP and related technologies for measurement of physical properties of wastes including particle properties, bubble properties, liquid and slurry densities and rheological properties using either in-tank or in-line sensors.

Budget Profile: Slurry Transfer and Tank Waste Mixing Monitors (TFA Technical Response 99078; Work Package WT-08-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL						
ORR						
SRS	SR18WT21	150				
WVDP						
TFA Total		150	0		TBD	TBD
ASTD						
CMST	FT00C211 OR17C231	250 100	500	250		
FETC						
ESP						
International						
Robotics						
University						
EM-50 Total		500	500	250	TBD	TBD

<u>Validate Analytical Procedures for Radioactive Waste Samples</u> (TFA Technical Response 99064; Work Package WT-11-01, unfunded)
Hanford, INEEL, and SRS need to develop and validate analytical procedures to address specific site requirements and issues. Hanford needs to validate, per EPA protocol or equivalency guidelines, existing laboratory procedures for waste samples. Hanford and INEEL have needs for analysis methods that minimize secondary waste generation, minimize

sample volumes, reduce analysis time, and reduce worker radiological exposure. Hanford and SRS need to validate laboratory procedures for technetium-99 analyses to increase confidence in contaminant inventory estimates. To address these needs, the TFA will

- Facilitate communications among the DOE sites regarding validation or demonstrating equivalency to EPA approved analytical methods.
- Optimize and upgrade laser ablation/mass spectroscopy (LA/MS) equipment and procedures for quantitative elemental analysis of solid samples. Validate LA/MS technology through round robin testing of standard materials and through continuance of EMSP fundamental studies of the laser ablation process.
- Conduct round-robin tests among laboratories across the DOE complex to validate Tc-99 analytical methods.
- Evaluate current analytical procedures and improve upon those methods to reduce secondary waste generation.
- The EM Science Program is funding several projects related to in situ waste analysis and chemical analysis methods validation. The TFA is interested in continuing relevant work through the science program and through applied research funding.

<u>In Situ Characterization</u> (TFA Technical Response 99055B; Work Package WT-11-01, unfunded)
In situ characterization methods are needed to support retrieval operations and waste pretreatment. Designing and deploying effective waste retrieval systems for tank wastes requires knowledge of the waste characteristics, such as the volumes and interface between supernate, sludge, and/or hard heel. Methods to map the sludge or heel level are needed for tanks where the bulk supernate remains, to allow for design of the retrieval system and retrieval strategy before supernate removal. Specifically, the ORR needs a sludge mapping system to measure the volume of sludge under the supernate before and after removal to assess vendor performance. Chemical characterization through in situ sensing is also needed to support tank closure decisions operations.

Sludge Mapping Tools - Work activities to support ORR needs for sludge mapping tools include

- Define requirements and identify deployment method for sludge mapping.
  - Define functions and requirements and identify deployment platform and mapping equipment for sludge mapping in ORR Melton Valley Storage Tank (MVST). **Decision point for procurement and demonstration.**
  - Initiate procurement, fabrication of system components, and cold testing of components.
- Assemble components, test, and deploy system for sludge-level measurements.
  - Complete mapping system assembly, calibration, and cold testing.
  - Initiate in-tank deployment.

In-Situ Waste Analysis – Work to address site needs for in-situ and in-line chemical and radiochemical analyses includes

- For application at WVDP, adapt the CdTe gamma-ray spectrometer probe designed for surveying the walls, bottom, and infrastructure of Hanford tanks.
- Develop real-time monitors for Cs/Sr and TRU process control during waste pretreatment pilot-scale testing and operations.
- Continue development of promising EMSP and related technologies for direct chemical and/or radiochemical analyses of radioactive wastes using either in-tank or in-line sensors.

Problem Element Description and Priority Site Needs

Secondary wastes, such as contaminated water from off-gas treatment systems, are generated during processing of tank wastes. Some liquid streams are 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 space and reduce life-cycle cost by reducing the volume of waste re-entering process plants. Tank farms are still receiving wastes even though many major mission operations have ceased at most of the sites. Some of these wastes result from decontamination and decommissioning (D&D) operations, from tank-to-tank transfers to solve waste storage problems, or from tank waste processing operations.

The site needs addressed by this problem element are identified below.

Problem Element: 1.1.4 Reduce Source Streams

STCG Need Number	Need Title	PBS Number	Technical Task	OST Number
SR99-1011	Demonstrate Evaporation Technologies to Reduce Generation of Secondary Waste Volume from Consolidated Incineration Facility	SR-SW01	Consolidated Incinerator Facility (CIF) Evaporator	20
ID-2.1.16	Decon Facility/Analytical Facility Waste Reduction	ID-HLW-101	Decontamination Methods Development	TBD
ID-2.1.17	Develop New Filter Leach Process	ID-HLW-101	Decontamination Methods Development	TBD
ID-2.1.36	Mercury Removal from Liquid Wastes	ID-HLW-101	Removal of Mercury from INEEL Waste Solutions	TBD
ID-2.1.56	Mercury Treatment for Aluminum Calcine	ID-HLW-103	Removal of Mercury from INEEL Waste Solutions	TBD
ID-2.1.30	Remove/Treat Chlorides	ID-HLW-101	Removal of Chloride from INEEL Waste Solutions	TBD

Technical Tasks

Consolidated Incinerator Facility (CIF) Evaporator (TFA Technical Response 99086; Work Package WT-09-01)
SRS has a need for a modular evaporator system to reduce the volume of liquid waste generated by their Consolidated Incinerator Facility (CIF). The CIF incinerates mixed, low-level, and hazardous wastes. The off-gas treatment system for the CIF generates a high salt, high-solids, high-liquid waste stream that is subsequently stabilized in drummed cement waste forms. Reducing the volume of the liquid waste will reduce the volume of the stabilized waste forms. Testing was conducted to provide input regarding design and operating parameters for the evaporator. Workscope to complete this activity includes

- Complete fabrication, delivery, and acceptance testing of the CIF evaporator (FY00, ASTD, EM-30).
- Complete laboratory testing to evaluate operating conditions and waste stabilization (FY00, ASTD, SRS, ORNL, EM-30).
- Install and cold test the CIF evaporator (FY00, ASTD, SRS, EM-30).
- Startup and begin operation of the CIF evaporator (FY00, ASTD, SRS, EM-30).
- Document performance of the CIF evaporator (FY01, ASTD).

Budget Profile: CIF Evaporator
(TFA Technical Response 99086; Work Package WT-09-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL						
ORR						
SRS						
TFA Total		0	0	TBD	TBD	TBD
ASTD	OR08SD11 SR09SD10	480 405	510			
CMST						
FETC						
ESP						
International						
Robotics						
University						
EM-50 Total		885	510	TBD	TBD	TBD

Decontamination Methods Development (TFA Technical Response 99003; Work Package WT-04-01)

Aggressive reductions in waste generation at INEEL are required to meet State of Idaho and DOE-ID goals to complete environmental management and treatment of current waste inventories. Several facilities at the INTEC, particularly the decontamination facility, the filter leach facility, and the analytical laboratories, are significant waste generators. By reducing the waste generation to the tank farm, meeting the Settlement Agreement schedule or deadline becomes more achievable. Reduction of analytical wastes is addressed in Problem Element 1.1.3, "Characterize Waste." Workscope to address this need includes

- Identify and evaluate waste volume minimization technologies (FY00, TFA, INEEL).
- Document laboratory studies and engineering analyses of waste minimization technologies (FY00, TFA, INEEL).
- Deploy waste volume minimization technologies (FY01, INEEL, TFA).
- Document performance of waste volume minimization technologies (FY02, INEEL, TFA).

Budget Profile: Decontamination Methods Development (TFA Technical Response 99003; Work Package WT-04-01)						
	TTP#	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Hanford						
INEEL	ID70WT32	485				
ORR						
SRS						
WVDP						
TFA Total		485	685	60	TBD	TBD

Removal of Mercury from INEEL Waste Solutions (TFA Technical Response 99018; Work Package WT-08-01)
Removal of mercury (Hg) is required to accomplish INEEL near-term waste management strategies by eliminating the Hg recycle to the waste tanks, thereby reducing the volume of waste requiring extensive treatment. Technologies are needed to remove Hg from INEEL off-gas treatment solutions, sodium-bearing wastes, and newly generated liquid wastes and from dissolved calcines that are planned for thermal treatment. Removal of mercury from DWPF recycle streams remains an SRS technology need. Both INEEL and SRS, through the ESP, have examined Hg removal methods. Workscope to complete this task includes

- Evaluate alternative Hg removal technologies (FY00, ESP, INEEL).
- Conduct lab-scale demonstration of Hg removal from actual waste solutions (FY01, ESP, INEEL).
- Conduct bench-scale testing on methods to remove Hg from dissolved calcine (FY01, ESP, INEEL).

Budget Profile: Removal of Mercury from INEEL Waste Solutions (TFA Technical Response 99018; Work Package WT-08-01)						
	TTP#	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Hanford						
INEEL						
ORR						
SRS						
WVDP						
TFA Total		0	0	600	TBD	TBD
ASTD						
CMST						
FETC						
ESP	RL00C311	450	490			
International						
Robotics						
University			120	100		
EM-50 Total		450	610	700	TBD	TBD

Removal of Chloride from INEEL Waste Solutions (TFA Technical Response 99014; Work Package WT-09-01, unfunded)

The need for chloride removal from INEEL waste treatment solutions is anticipated to minimize corrosion of primary and secondary waste treatment processes. To address this need, the following tasks must be completed

- Conduct laboratory corrosion studies on INEEL materials of construction.
- Identify and evaluate alternative methods for removing chlorides from INTEC wastes.
- Demonstrate selected chloride removal methods.

Problem Element Title: 1.2.1.2 Mobilize Bulk and Heel Wastes

Problem Element Description and Priority Site Needs

Mobilizing bulk and heel wastes within a tank is required for tank waste retrieval and treatment, for ultimate immobilization and disposal of the hazardous waste components, and for tank closure. 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. The site needs addressed by this problem element are identified below.

Problem Element: 1.2.1.2 Mobilize Bulk and Heel Wastes				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
RL-WT013	Establish Retrieval Performance Evaluation Criteria (SST Retrieval Enhancements)	RL-TW04	Tank Heel Retrieval Technology	812, 1510, 1511, 1547, 1989, 2011, 2012, 2097 2117, 2232, 2366, 2370
RL-WT060	PHMC Retrieval and Closure – Hanford/SRS Waste Mixing Mobilization	RL-TW04	Hanford/SRS Mixing and Mobilization	1511, 2097, 2115, 2232, 2370
RL-WT062	PHMC DST Retrieval – Hanford DST Transfer Pump Improvements	RL-TW04	Hanford/SRS Mixing and Mobilization	1511, 2097, 2115, 2232, 2370
RL-WT063	PHMC Retrieval and Closure – Hanford SST Saltcake Dissolution Retrieval	RL-TW04	Saltcake Dissolution Retrieval	1989
RL-WT064	PHMC Retrieval and Closure – Hanford Past Practice Sluicing Improvements	RL-TW04	Tank Heel Retrieval Technology	812, 1510, 1511, 1989, 2011, 2012, 2097, 2117, 2232, 2366, 2370
SR99-2028	Alternative Waste Removal Technology	SR-HL01, SR-HL02, SR-HL03	Hanford/SRS Mixing and Mobilization	1511, 2097, 2115, 2232, 2370
SR99-2037	Tank Heel Removal/Closure Technology	SR-HL01, SR-HL02, SR-HL03	Hanford/SRS Mixing and Mobilization Tank Heel Retrieval Technology	812, 1510, 1511, 1989, 2011, 2012, 2097, 2117, 2232, 2366, 2370
SR99-2041	Demonstration of Alternative Mixer Technology for HLW Pump Tanks	SR-HL01, SR-HL02, SR-HL03	Hanford/SRS Mixing and Mobilization	1511, 2097, 2115, 2232, 2370
ID-2.1.50	Solids Waste (Calcine) Retrieval	ID-HLW-103	Dry Solid Wastes Retrieval	N/A
OH-WV-905	WVDP Tank Heel Removal	OH-WV-01	Retrieval of Tank Heels	

Problem Element: 1.2.1.2 Mobilize Bulk and Heel Wastes				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
OR-TK-02	ORNL Tank Solid Waste Retrieval	OR-321, OR-322	Tank Heel Retrieval Technology Horizontal and Small Tank Sludge Mixing and Mobilization	812, 1510, 1511, 1989, 2011, 2012, 2097, 2117, 2232, 2366, 2370
OR-TK-03	ORNL Sludge Mixing and Mobilization	OR-311	Horizontal and Small Tank Sludge Mixing and Mobilization	1511, 2086, 2232, 2370

Technical Tasks

Hanford/SRS Waste Mixing and Mobilization (TFA Technical Response 99059; Work Package WT-02-01)

This activity combines Hanford and SRS needs for mixer pump retrieval enhancements. Mixer pump retrieval consists of waste mobilization and transfer out of the tank.

SRS is resuming sludge retrieval using its baseline long-shaft mixers. They need to optimize their operational strategy so that as much sludge as possible can be sent to DWPF as feed. This will require testing of multiple pump retrieval interactions. Hanford may use the results of the SRS work for long-shaft mixer equipment and operational improvements as candidate recommendations for their sludge retrieval activities. Hanford needs additional sludge mobilization methods to retrieve sludge that is beyond the Effective Cleaning Radius (ECR) of the baseline pair of long-shaft mixer pumps. The objective is a small system that can be installed in the tanks along with the mixers when needed to mobilize remaining sludge. Both Hanford and SRS are interested in identifying replacements for baseline mixer pumps with more cost-effective alternates, especially with respect to life-cycle and operations costs for bulk sludge, sludge heel, and saltcake retrieval. This need exists in large HLW storage tanks and in smaller process tanks, such as SRS transfer system pump tanks. SRS also desires recommendations for equipment enhancements such as a small diameter 300 Hp Slurry pump, or a pump deployment system that simplifies elevation changes. Safety impacts to Authorization Bases also need to be evaluated.

Hanford also requires, as part of their mixer pump retrieval operations, a means of retrieving waste from a tank that is actively mixing waste. However, they also need to retrieve the waste at the optimum depth for a given delivery requirement. The need is to transfer waste without having to change pumps for surface decant and bottom or sludge transfer operations with attendant low water level conditions. Additionally, SRS is looking for equipment and operational enhancements for their Telescoping Transfer Pump. Workscope to complete these activities includes

- Mixer Pump (Slurry Pump) Operational Improvements
  - Complete multiple pump tests, evaluate results, and recommend operational requirements for best pump performance (FY00, TFA, SRS).
  - Issue operational strategy for mixer pump testing in SRS tanks (FY00, TFA, SRS).

  - Demonstrate operational improvement of SRS mixer pump (FY01, TFA, SRS).
- Extended Sludge Retrieval
  - Complete evaluation of extended sludge retrieval systems and recommend deployable systems (FY00, TFA, Hanford). **Decision point for deployment.**
  - Procure system for extended sludge retrieval (FY01, Hanford, TFA, FETC).
  - Deploy extended sludge retrieval system (FY03, Hanford, TFA).
- Alternate Mixer Systems
  - Complete evaluation of long-shaft mixers, Flygt mixers, and Russian Pulsating Mixer Pump for application at Hanford and SRS (FY00, TFA, Hanford, SRS). **Decision point for deployment at Hanford.**
  - Conduct full-scale Flygt mixer tests at TNX technical facility and document results (FY00, TFA, SRS).
  - Deploy Flygt mixers in Tank 19 at SRS (FY00, SRS, TFA).
  - Procure alternate mixer system for Hanford (FY02, Hanford, FETC, TFA).
  - Complete cold testing of alternate mixer system for deployment at Hanford (FY03, Hanford, TFA).
- SRS Pump Tank Mixer
  - Issue preliminary design package for SRS organic pump tank mixer (FY00, TFA, SRS, AEAT).
  - Complete acquisition of the organic layer pump tank mixer (FY01, TFA, SRS).
  - Deploy organic layer pump tank mixer (FY02, TFA, SRS).
- Variable Depth Retrieval Pumps
  - Identify and evaluate candidate variable depth transfer pumps (FY00, TFA, Hanford).
  - Complete feature tests on variable depth transfer pumps for Hanford and telescoping transfer pump for SRS (FY00, TFA, Hanford, SRS).
  - Procure variable depth transfer pump for Hanford (FY01, FETC, Hanford, TFA).
  - Deploy variable depth transfer pump into DST at Hanford (FY03, Hanford, TFA).

Budget Profile: Hanford/SRS Waste Mixing and Mobilization
(TFA Technical Response 99059; Work Package WT-02-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL09WT22 RL36WT51	425 675				
INEEL						
ORR						
SRS	SR16WT51	700				
WVDP						
TFA Total		1800	2700	3100	TBD	TBD
ASTD						
CMST						
FETC	FT06IP01	0	1200	300		
ESP						
International	AEAT	100	0	0		
Robotics						
University						
EM-50 Total		1900	3900	3400	TBD	TBD

Horizontal and Small Tank Sludge Mixing and Mobilization (TFA Technical Response 99082; Work Package WT-02-01)
Process heels inside Federal Facilities Agreement (FFA) tanks (50-5000 gal. tanks) at ORR, and OBG tanks and the 1F Evaporator at SRS, must be removed in order to remediate these tanks. These tanks are generally made of carbon or stainless steel and have limited access (usually one entrance port). In addition, mixing and mobilization systems to remove bulk quantities of sludge from ORNL horizontal 50,000-gal stainless steel underground storage tanks (MVSTs) need to be identified. These tanks have limited access and internal obstructions. The TRU waste processing privatization treatment vendor will implement the technologies. The technology must be accepted by this vendor. As a separate but related case, the new Melton Valley Capacity Increase Tanks (MVCITs) require retrieval systems that can remain unused in sludge for years until called upon to remove the waste.

Several technologies have been recently demonstrated or are nearing demonstration that could be applicable to both large horizontal and smaller tanks. Functions and requirements for a tank typical of the FFA and MVCIT tanks at ORR and the OBG tanks and 1F Evaporator at SRS will be determined and coordinated with ASTD efforts. A small tank retrieval system will be built, tested and deployed in a FFA tank and evaluated, along with other available technologies for adaptation to OBG tanks that have very small access ports. The equipment selected for OBG retrieval will be considered for deployment in the 1F CTS Pump Tank at SRS as well. Peripheral equipment, such as vision systems that can be inserted through small openings to assess initial and final waste amounts, will be identified and developed. A feasibility study will be conducted to identify candidate technologies for MVST tank retrieval to support MVST privatization efforts. Pros, cons, and issues will be identified for each technology identified. If needed, process feature tests will be conducted to verify or alter findings.

AEAT Fluidic Pulse Jet Mixers have been deployed in BVEST W-21, -22, and -23. Waste removal is complete. The BVEST retrieval system was co-funded by the TFA in FY97. The extendible nozzle "Borehole Miner" has been successfully deployed to clean out OHF tanks. AEAT has retrieved waste in BVEST Tanks C-1 and C-2 with a transportable Pulsejet Mixer. A Pulsejet mixing system is being installed in the new MVCIT tanks. AEAT has prepared a concept design for retrieval of wastes from FFA tanks. Other retrieval equipment for GAAT tanks could also be adapted for the MVST, such as Flygt Mixers, the Russian Pulsating Mixer Pump, and the Scarab II remotely operated vehicle.

Workscope to complete technology delivery for horizontal and small tank sludge mixing and mobilization includes

FFA Tank Retrieval
- Deploy FFA retrieval system (FY00, ASTD, ORR, TFA).
- Document performance of FFA retrieval system (FY00, ASTD, ORR, TFA).

Horizontal Tank Retrieval Systems

- Evaluate data and provide recommendations regarding retrieval systems for MVST retrieval (FY00, TFA, ORR).

Old Burial Ground/CTS Pump Tank Retrieval Systems

- Issue recommendations for SRS OBG/CTS pump tank retrieval system (FY00, SRS, TFA).
- Deploy CTS pump tank retrieval system (FY01, SRS, TFA).
- Deploy OBG retrieval system, if required (FY01, SRS, TFA).
- Document performance of OBG retrieval system (FY01, SRS, TFA).

1F Evaporator Retrieval

- Deploy sampling system in 1F evaporator at SRS (FY00, SRS, TFA).
- Develop and deploy retrieval system for 1F Evaporator (FY01, SRS, TFA).

Budget Profile: Horizontal and Small Tank Sludge Mixing and Mobilization (TFA Technical Response 99082; WT-02-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL36WT51 RL09WT21	150 325				
INEEL						
ORR	OR16WT51	75				
SRS	SR16WT51	350				
WVDP						
TFA Total		900	1250	TBD	TBD	TBD
ASTD	OR09WT41	101				
CMST						
FETC						
ESP						
International						
Robotics						
University						
EM-50 Total		1001	1250	TBD	TBD	TBD

Tank Heel Retrieval Technology (TFA Technical Response 99067; Work Package WT-03-01)
After conventional waste rertieval techniques remove the bulk of the wastes within a tank, tank heels usually remain. Removal of the tank heels is required to maximize the amount of waste delivered to waste treatment and immobilization processes and to minimize the amount of waste remaining in the tanks for tank closure. Heel retrieval systems are needed that 1) minimize the amount of water added to the tank, 2) retrieve rapidly settling solids, and 3) retrieve waste heels from tanks with various floor obstructions.

The tank heel retrieval technology activity has three parts:

A) Heel Retrieval from Unobstructed Tanks. Here, deployment of systems such as vehicles and sluicers is unrestricted by cooling coils or other tank structures. These include SRS Type

IV tanks, ORR GAAT tanks, and most Hanford SSTs. The performance of equipment used to date will be analyzed. Requirements will be established for retrieval of remaining waste heels. A flat tank bottom cleaning system is needed for ORR and SRS that will likely be vehicle deployed. The needed equipment will be assembled for use at ORR and SRS. Retrieval systems for removal of coarse sand-like gunite chips and rubble from Tank W-9 at ORR that remain will be evaluated for deployment. This material that will likely not be a candidate for pipeline transfer to MVST. Alternate waste transfer methods must be evaluated. The Hanford C-106 heel retrieval project (formerly known as the Hanford Tanks Initiative) identified several alternate retrieval technologies that could be suitable to remove hard heel waste from leaking tanks; provide characterization technologies for in-tank and the vadose zone; and provided retrieval performance evaluation criteria. ORR has deployed the Borehole Miner in their OHF tanks and the Gunite Tank Cleaning system, consisting of the Modified Light Duty Utility Arm, Houdini, and Houdini II, the Confined Sluicing End-Effector, and the Hose Management system, in the ongoing retrieval of waste from the GAAT.

B) Heel Retrieval from Obstructed Tanks. These include SRS Type I, II, and III Tanks, INEEL HLW tanks, WVDP HLW tanks, and some Hanford SSTs. Following bulk waste retrieval from Type I or II (Tank 8) tanks at SRS using a long-shaft mixer, the residual waste heel will be evaluated for removal using a secondary retrieval system, such as a sluicer and retrieval pump. The utility of advanced sluicing systems and efficient scavenging pumps for tank cleaning will be investigated. Recommendations will be prepared for Hanford, SRS, WVDP, and INEEL as to viable options available. This is also applicable for unobstructed tank waste retrieval.

C) Chemical Tank Cleaning. The primary goal of chemical cleaning is to remove all the residual contaminants from a waste tank. However, when this is not practical, enhancing the removal of Tc-99 is desirable because Tc-99 has the highest public dose potential after tank closure. Tc-99 becomes more soluble when oxidized, so oxidizing chemical treatments, such as peroxides or ozone, could be effective. Development of improved chemical cleaning methods with the assistance of Russian scientists will lead to recommendations for hot chemical cleaning methods in FY00. Primary issues include criticality safety during waste dissolution or softening, prevention of tank walls and floor disintegration, and improved methods that minimize impacts on downstream treatment processes. Chemical cleaning developments will consider bulk sludge removal, residual heel removal, and selective Tc-99 removal. Investigation of using chemical additions to enhance mechanical retrieval methods will also be evaluated, particularly related to increasing retrieval performance in obstructed tanks.

Workscope to provide technology solutions for tank heel retrieval includes

- Heel Retrieval from Unobstructed Tanks (ORR)
  - Deploy Russian Pulsating Mixer Pump (FY00, ASTD, ORR, TFA).
  - Document performance of Russian Pulsating Mixer Pump (FY00, ASTD, ORR, TFA).

  - Complete design, fabrication, and cold testing of Heavy Wastes Retrieval System (HWRS) (FY00, ASTD, ORR, Robotics, TFA).
  - Evaluate options of combining operations of Russian Pulsating Mixer Pump, Flygt Mixers, Pulsed Air System, Houdini, Modified Light Duty Utility Arm, and HWRS to enhance retrieval from GAAT W-9 (FY00, ASTD, ORR, TFA).
  - Deploy HWRS in GAAT W-9 (FY00, ASTD, ORR, TFA).

- Heel Retrieval from Unobstructed Tanks (Hanford)
  - Issue recommendation document for SST heel retrieval at Hanford (FY00, FY01, Hanford, TFA).
  - Design and fabricate residual waste retrieval system for Hanford SSTs (FY02, Hanford, TFA).
  - Complete testing of alternative sluicing nozzles for application in unobstructed tanks (FY00, TFA).

- Heel Retrieval from Unobstructed Tanks (SRS)
  - Evaluate performance of Flygt Mixers in Tank 19 retrieval (FY00, SRS, TFA).
  - Deploy SRS crawler in Tank 19 for residual heel removal and floor cleaning (FY00, SRS, TFA).
  - Complete heel removal and floor cleaning campaign and document performance (FY00, SRS, TFA).
  - Issue decision regarding residual waste retrieval technology for SRS Tank 18 (FY01, SRS, TFA).
  - Complete procurement and cold testing of next generation heel removal system for Tank 18 deployment (FY02, SRS, TFA).

- Heel Retrieval from Obstructed Tanks (WVDP)
  - Complete cold testing of the Advanced Waste Retrieval System (AWRS) for application with the Mast-Mounted Tool Deployment System at WVDP (FY00, WVDP, TFA).
  - Complete upgrades to Tool Deployment System and associated tools (FY01, ASTD, WVDP, Robotics, TFA).

- Heel Retrieval from Obstructed Tanks (SRS)
  - Evaluate benefit of deploying secondary waste retrieval system for wastes remaining in Tank 8 after mixer pump retrieval operations (FY00, SRS, TFA).
  - Evaluate and recommend retrieval methods for Tank 8 heel retrieval (FY00, TFA, SRS).
  - Evaluate recommended systems for heel removal equipment for Type I, II, and III tanks (FY01, SRS, TFA).
  - Procure/fabricate heel retrieval equipment (FY01, SRS, TFA).
  - Deploy heel retrieval equipment for SRS Type I, II, and III tanks (FY02, SRS, TFA).
  - Document performance of heel retrieval equipment for SRS obstructed tanks (FY02, SRS, TFA).

- Chemical Tank Cleaning (SRS)
  - Complete cold verification testing of chemical cleaning methods recommended as a result of Russian V. G. Khlopin Radium Institute work (FY00, SRS, TFA, Khlopin Radium Institute).
  - Conduct radioactive laboratory-scale demonstration of chemical cleaning methods (FY01, SRS, TFA).
  - Deploy chemical cleaning system (FY02, SRS, TFA).
  - Document performance of chemical cleaning system (FY02, SRS, TFA).
  - Issue report on Khlopin Radium Institute studies of chemical cleaning methods including methods to soften bulk hardened sludges and to selectively remove Tc-99 (FY00, FY01, FY02, Khlopin Radium Institute, TFA).

Budget Profile: Tank Heel Retrieval Technology
(TFA Technical Response 99067; Work Package WT-03-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL36WT51 RL09WT22	1000 100				
INEEL						
ORR						
SRS	SR16WT51	1100				
WVDP	OH00WT22	625				
TFA Total		2825	3925	5100	TBD	TBD
ASTD	OR08SD10	400				
CMST						
FETC						
ESP						
International	HQ06T222	100	100	100		
Robotics	OR17C131	300	200			
University						
EM-50 Total		3650	4225	5200	TBD	TBD

Saltcake Dissolution Retrieval (TFA Technical Response 99062; Work Package WT-02-01, unfunded)

The Low-Volume Density Gradient (LVDG) retrieval method has been proposed as a less costly system for SST saltcake retrieval at Hanford. By placement of a single or multiple sprinklers through a riser into a SST, water can be added to the tank, allowing the saltcake to dissolve. As the dissolution proceeds, a transfer pump can transfer the dissolved salt out of the tank and into a feed staging tank. This method appears to be significantly less expensive and less complex than past practice sluicing for saltcake retrieval. Performance data and retrieval efficiency data are needed and the impacts to in-tank hardware and tank walls need to be determined. The chemistry involved in this process is addressed in Problem Element 1.2.2.3, "Prepare Retrieved Waste for Transfer and Pretreatment." Workscope to complete this activity includes

- Conduct pilot-scale testing of LVDG concept to evaluate process and determine impacts to tanks.
- Procure LVDG system for full-scale demonstration.
- Conduct cold demonstration of full-scale LVDG system.

- Deploy LVDG system.

Dry Solid Waste Retrieval (TFA Technical Response 99031; Work Package WT-02-01) Highly radioactive waste material is stored in seven Calcined Solids Storage Facilities (CSSFs) at INEEL. The calcine was in the form of granular solids or powder when it was sent to storage. Some calcine may have formed a cake, bridge or other agglomeration during storage. Systems are needed to retrieve the granular solids and any caked material from the storage bins and to transfer the materials to a processing facility for treatment and immobilization. Bin Set 1 requires access risers to be installed to enable performance of sampling and retrieval operations. Riser attachments and cutting methods must be designed and cold tested before hot deployment.

Preliminary investigations at INEEL have been conducted with EM-30 funds to identify requiements for retrieval of the calcine waste. Additional work is needed to identify and resolve open issues before designing a dry retrieval system for the INEEL calcine bins. Workscope to complete this activity includes

- Provide a riser attachment and cutting method for Bin Set 1 to enable calcine sampling.
- Complete calcine sampling and characterization, including dislodging testing.
- Identify and evaluate commercial retrieval and transfer systems for dry retrieval.

Budget Profile: Dry Solid Waste Retrieval
(TFA Technical Response 99031; Work Package WT-02-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL	ID70WT21	340				
ORR						
SRS						
WVDP						
TFA Total		340	450	300	TBD	TBD

Problem Element Description and Priority Site Needs

Waste transfer operations are required after retrieval to move the waste to storage, to provide supernate for use in a retrieval operation, or to stage wastes for subsequent blending or pretreatment. Transfers may occur from tank-to-tank or tank-to-processing facility and can cover a distance of several miles. During transfers, pipeline plugging has occurred at most sites and can result in very costly delays and intensive efforts to mitigate the plugging. Methods are needed to prevent plugging and to mitigate plugged lines if it cannot be avoided. The site needs addressed in this problem element are identified below.

Problem Element: 1.2.1.4 Transfer Waste				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
OR-TK-02	ORNL Tank Solid Waste Retrieval (Waste Conditioning)	OR-321 OR-322	Waste Conditioning for Transfer	1510, 85, 810, 890, 1547, 2115
SR99-2039	Methods to Unplug Waste Transfer Lines	SR-HL01, SR-HL02, SR-HL04	Pipeline Unplugging	N/A

Technical Tasks

Waste Conditioning for Transfer (TFA Technical Response 99054A; Work Package WT-08-01)

ORR is conducting transfer operations through existing pipelines and is concerned about the plugging impacts during transfers. The site developed a waste conditioning system to size-reduce waste particles for transfer through a long up-and-down pipeline to storage. In FY99, the system successfully pumped slurry from the GAAT Waste Consolidation tank and was used to discriminate and verify size and concentration. As the lighter constituents are removed, heavier materials will be prepared for transfer. The performance of these heavier slurries in off-normal conditions during transfer needs to be characterized to optimize the transfer and prevent pipeline plugging.

This task involves size reduction and solids monitoring to support the Waste Conditioning Compact Processing Unit (CPU), which is jointly funded by the TFA and the ASTD Program. Workscope to complete this activity includes

- Complete hot deployment of Waste Conditioning CPU size reduction system (FY00, ASTD, ORR).
- Complete Waste Conditioning CPU operations (FY01, ASTD, ORR).
- Document performance of Waste Conditioning CPU (FY01, ASTD, ORR).

Budget Profile: Waste Conditioning for Transfer (TFA Technical Response 99054A; Work Package WT-08-01)						
	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL						
ORR						
SRS						
WVDP						
TFA Total		0	0	TBD	TBD	TBD
ASTD	OR08SD10	200	250			
CMST						
FETC						
ESP						
International						
Robotics						
University						
EM-50 Total		200	250	TBD	TBD	TBD

<u>Pipeline Unplugging</u> (TFA Technical Response 99076; Work Package WT-01-01)
As the tank cleanout and decommissioning program becomes active at SRS, increasing potential exists that current transfer lines will become plugged (the DWPF recycle evaporator drain line plugged in August 1997). Transfer systems will potentially become plugged if the solids concentration of the material being transferred increases beyond the capacity of the prime mover, which could be a jet or a pump. This can happen due to the solids settling out within the pipe, as well as chemical precipitation/crystallization. Safe and cost-effective pipeline unplugging systems are needed to mitigate future problems. Chemical methods for pipeline unplugging are being investigated as described in Problem Element 1.2.2.3, "Prepare Retrieved Waste for Transfer and Pretreatment."

Pipeline unplugging is important to SRS, Hanford, and ORR. Three key issues will be examined with regard to transfer line blockages. First, there needs to be an understanding of the factors that contribute to line blockage. Identifying these factors will enable the implementation of programs and processes to help prevent the formation of blockages. Second, once a blockage has occurred there must be a method to locate and evaluate the blockage. Third, once the blockage is located and evaluated, there must be a method of unplugging the line without causing damage. Related activities will be conducted to develop waste conditioning methods and procedures to reduce the potential for pipeline plugging (Problem Element 1.2.2.3). Work activities to support SRS needs for pipeline unplugging will include

- Identify chemical and physical parameters that influence pipeline plugging.
    - Complete tests to determine minimum settling velocity for particles, erosion factors, and the potential for precipitation and adherence of waste to pipe walls during transport (FY00, TFA, University Programs).
    - Test gelation plugging and other effects of gelation on transfer conditions (FY00, TFA, University Programs).

- Demonstrate blockage location tools.
    - Select industrial partners to provide and demonstrate tools to locate and/or evaluate transfer line blockages (FY00, TFA, EM-50 Industry Programs).
    - Develop and test transfer line blockage location tools (FY00, TFA, EM-50 Industry Programs).
    - Demonstrate industry technologies for locating blockage and evaluate performance using simulants (FY01, TFA, EM-50 Industry Programs, EM-50 University Programs). **Decision point for demonstration.**
- Demonstrate blockage removal tools.
    - Select industrial partners to provide and demonstrate tools to remove blockages from transfer lines (FY00, TFA, EM-50 Industry Programs).
    - Develop and test transfer line blockage removal tools (FY00, TFA, EM-50 Industry Programs).
    - Demonstrate industry technologies for removing pipeline blockages and evaluate performance using simulants (FY01, TFA, EM-50 Industry Programs, EM-50 University Programs). **Decision point for demonstration.**
    - Conduct hot demonstration of pipeline unplugging equipment. (FY02, TFA, SRS)
- Demonstrate pipeline inspection tools using Florida International University (FIU) test bed.
    - Select industrial partners to provide and demonstrate tools to inspect transfer lines (FY01, TFA, EM-50 Industry and University Programs).
    - Test pipeline inspection tools (FY02, TFA, EM-50 Industry and University Programs).
    - Conduct hot demonstration of pipeline inspection tool (FY02, TFA, SRS).

Budget Profile: Pipeline Unplugging
(TFA Technical Response 99076; Work Package WT-01-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL36WT51	200				
INEEL						
ORR						
SRS						
WVDP						
TFA Total		200	675	1275	TBD	TBD
ASTD						
CMST						
FETC	FT06IP01	400	400	200		
ESP						
International						
Robotics			100			
University		525	675	700		
EM-50 Total		1125	1850	2175	TBD	TBD

Problem Element Description and Priority Site Needs

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 drywells, 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. The site needs addressed in this problem element are identified below.

Problem Element: 1.2.1.5 Detect and Mitigate Leaks				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
RL-WT026	Tank Leak Detection Systems for Underground Single-Shell Storage Tanks	RL-TW04	Leak Detection, Mitigation, and Repair	N/A
RL-WT027	Tank Leak Mitigation Systems	RL-TW04	Leak Detection, Mitigation, and Repair	N/A

Technical Tasks

Leak Detection, Mitigation and Repair (TFA Technical Response 99057; Work Package WT-03-01

The use of past-practice sluicing for removing waste from SSTs involves adding liquid to tanks, therefore increasing the potential for waste leakage to the environment These waste removal methods (using liquids) require leak detection methods and leak mitigation and repair methods in the event a leak occurs.

The TFA, in conjunction with CMST Program, made investments in leak detection technology and adapted a subsurface plume remediation monitoring technology (electrical resistance tomography) for detecting leaks from radioactive waste 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 was demonstrated. This approach is now ready for field demonstration and deployment. This technology must be evaluated, along with other potential leak detection methods, for application at waste tank facilities.

Leak mitigation systems that improve on the current baseline approach are needed. The objective is to prevent, curb, or eliminate the possibility or extent of liquid waste leakage from underground storage tanks into the surrounding soils. If cost-benefit, risk-reduction, and alternative evaluations of new mitigating technologies determine that deployment, implementation, and operation are feasible, then further evaluation should be pursued. Such evaluations may include demonstrations and testing. Example concepts that could be evaluated include retrieval methods that minimize the potential for leakage, leak point and potential leak point location, "seek-and-seal" devices and methods, administrative approaches that maximize the use and coordination of currently available tools and methods, sheet barriers, close-coupled grout injection barriers, and dry-air containment barriers.

Workscope to address the need for leak detection and leak mitigation and repair systems includes

- Identify and evaluate leak detection systems
  - Define functions and requirements for leak detection system (FY00, TFA, Hanford).
  - Review and evaluate current leak detection systems available through industry, the DOE complex, universities, and under development (FY01, TFA, Hanford).
  - Develop and demonstrate tank leak detection system (FY02, TFA, TBD).
  - Conduct hot demonstration of leak detection system (FY03, TFA, Hanford).

- Identify and evaluate leak mitigation and repair systems
  - Develop and demonstrate tank leak detection system (FY02, TFA, TBD).
  - Conduct hot demonstration of leak detection system (FY03, TFA, TBD).

Budget Profile: Leak Detection, Mitigation, and Repair
(TFA Technical Response 99057; Work Package WT-03-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL00WT21	300				
INEEL						
ORR						
SRS						
WVDP						
TFA Total		300	300	TBD	TBD	TBD

Problem Elements Description and Priority Site Needs

Calcination is the baseline technology at INEEL for solidifying liquid HLW and storing it as a granular solid in underground stainless steel bins. This problem element addresses development of methods to dissolve currently stored calcine to support future radionuclide separations that are part of the baseline plan for waste processing at the INEEL. The site needs addressed in this problem element are shown below.

Problem Element: 1.2.2.1 Calcine Waste and 1.2.2.2 Dissolve Waste				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
ID-2.1.51	Develop Calcine Dissolution Kinetics for Solid/Liquid Equilibria	ID-HLW-1003	Calcine Dissolution	881

Technical Tasks

Calcine Dissolution (TFA Technical Response 99032; Work Package WT-11-01)
The waste processing baseline plan for INEEL includes a separations flowsheet option and requires dissolution of calcine before radionuclide separation. Calcine must be dissolved to a form that is compatible with radionuclide separation technologies. Parameters affecting dissolution efficiency must be defined, and scale-up and design of a calcine dissolver must be completed to support Title 1 design.

Work activities to support INEEL's need for calcine dissolution will include

- Develop dissolution rate and kinetic expressions for calcine dissolution.
  - Complete laboratory tests to determine rate and kinetic expressions for calcine dissolution using surrogate and actual calcine waste (FY00, TFA, EM-30).
- Evaluate dissolver equipment designs and test preferred concepts at a bench-scale.
  - Complete conceptual design of pilot plant dissolver based on laboratory kinetics experiments.
  - Demonstrate calcine dissolution at the bench-scale using surrogate wastes and pilot-plant design. Validate design and scale-up relationships from laboratory scale (FY01, TFA, EM-30). **Decision point for demonstration.**

Problem Element Title: 1.2.2.2 Dissolve Waste

Budget Profile: Calcine Dissolution
(TFA Technical Response 99032; Work Package WT-11-01)

	TTP#	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Hanford						
INEEL	ID70WT32	200				
ORR						
SRS						
WVDP						
TFA Total		200	300	TBD	TBD	TBD
ASTD						
CMST						
FETC						
ESP						
International	AEAT	100	100			
Robotics						
University						
EM-50 Total		300	400	TBD	TBD	TBD

Problem Element Description and Priority Site Needs

Waste transfers and pretreatment facilities will require feed streams that can be transferred without plugging pipelines and are compatible with pretreatment unit operations (e.g., density, solids content, rheology, particle size, blending reactions, chemistry). Physical and chemical properties of tank waste can impact the efficiency of pretreatment. Various chemical combinations can lead to gelation or precipitation, which will adversely impact transfers and processing. A better understanding of sludge and saltcake chemistry and its impact on dissolution rates, pipeline transfers, and mixing operations is needed. This "interface" with retrieval and transfer focuses on understanding the effects of properties on waste transfer and pretreatment process efficiency. This will ensure selection of appropriate operating parameters and performance requirements during retrieval, conditioning, transfer, and storage of wastes. The site needs addressed in this problem element are identified below.

Problem Element: 1.2.2.3 Prepare Retrieved Waste for Transfer and Pretreatment				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
ID-2.1.15	Neutralization of Newly Generated Liquid Wastes	ID-HLW-103		N/A
OR-TK-02	Tank Solid Waste Retrieval	OR-321 OR-322		233, 2096, 2367
RL-WT023	Prediction of Solid Phase Formation in Hanford Tank Waste Solutions	RL-TW04	Prevention of Solids Formation and Saltcake Dissolution	233, 1989, 2096, 2367
RL-WT063	PHMC Retrieval and Closure – Hanford SST Saltcake Dissolution Retrieval	RL-TW04		1989, 2096
SR99-2039	Methods to Unplug Waste Transfer Lines	SR-HL01, SR-HL02, SR-HL03	Prevention of Solids Formation and Saltcake Dissolution	233, 2096, 2367

Technical Tasks

Prevention of Solids Formation (TFA Technical Response 99054A; Work Package WT-08-01)

Understanding the phenomena of line plugging and scale buildup associated with waste retrieval, transfer, and treatment is needed to define operating conditions for these activities and to identify methods for pipe plug recovery. This work provides the chemical and thermochemical understanding of pipeline plugging and is closely related to work in Problem Element 1.2.1.4, "Transfer Waste," in which methods to unplug pipelines are being developed.

At SRS, pipeline plugs are due to sodium aluminosilicates in the wastes. The solubilities of key components need to be determined as functions of temperature, and safe transfer conditions need to be identified.

Solids and gels can form in Hanford tank wastes when the solution ionic strength is decreased. Transfer lines have plugged in the past due to solids or gel formation.

Knowledge of the solubility envelope for the waste is necessary to avoid unwanted precipitation or gel formation in supernate. The immediate need is for information on the dynamics of solid phase formation and solubility envelopes for the DST supernate and saltcake to support waste retrieval and transfers, feed staging, and waste processing at Hanford. Hanford needs to understand both gel formation during supernate transfers and settling during slurry transfers. This will enable the site to identify and implement operational measures and controls to prevent pipeline plugging.

Studies of the chemistry and thermochemistry of Hanford's tank wastes are underway. The chemistry and solubility of key components such as aluminates, fluorides, phosphates, and silicates are being studied. The results of these studies are being incorporated into equilibrium models such as the Environmental Simulation Program (ESP) and kinetics models such as FACSIMILE. Tests will be conducted to understand chemical dynamics in engineered systems for waste transport and reciept. The effects of temperature, chemical system, and flow conditions on waste transfers will be determined.

Work activities to support Hanford and SRS needs for confirmation and improvement of thermodynamic predications of waste solubility and reaction kinetics to support processing and transfer operations will include

- Provide final recommendations for operating envelopes for Hanford waste transfers (FY01).
- Complete laboratory studies of chemical methods to remove pipeline plugs at Hanford (FY01).
- Provide data and models on waste stability during transport (FY00, FY01).
- Develop and demonstrate engineering tools to predict the stability of Hanford waste feeds during transport (FY00, FY01).
- Provide data on thermal properties of compressing sediments in tanks (FY00).
- Provide data on chemical plugs and kinetics at SRS (FY00).
- Complete laboratory studies of chemical methods to remove pipeline plugs at SRS (FY01).
- Provide final recommendations for operating envelopes for SRS waste transfers (FY02).
- EMSP is funding several projects related to waste and radionuclide chemistry. The TFA is interested in continuing relevant work through the science program and through applied research funding.
  - Continue EMSP and related research studies on the chemistry of aluminum, nitrates, and other species including the kinetics and thermodynamics of waste dissolution, precipitation, gelation, and gas/foam formation, particularly in relation to waste processing and pipeline plugging.
  - Continue EMSP and related research studies on the chemistry of strontium, uranium, and actinides in waste processing operations.
  - Continue EMSP and related research studies on the effects of organics and aging of organics on waste processing.

Budget Profile: Prevention of Solids Formation
(TFA Technical Response 99054A; Work Package WT-08-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL09WT32 RL08WT41	500 75				
INEEL						
ORR	OR16WT41	625				
SRS	SR19WT31	100				
WVDP						
TFA Total		1300	2150	1400	TBD	TBD
ASTD						
CMST						
FETC						
ESP						
International						
Robotics						
University		250	175	75		
EM-50 Total		1875	2450	1475	TBD	TBD

Saltcake Dissolution (TFA Technical Response 99054B; Work Package WT-08-01)
At Hanford, saltcake will be retrieved for subsequent treatment and immobilization. The baseline approach for retrieval of saltcake involves aqueous dissolution. Two saltcake retrieval processes, past-practice sluicing and low-volume density gradient, are currently under consideration. The chemistry of the dissolved saltcake is expected to be very complex and the dilution of the dissolved saltcake can lead to additional solids formation such that the wastes would not meet feed specifications. The chemistry of saltcake dissolution is studied here, while the retrieval processes are described in Problem Element 1.2.1.2, "Mobilize Bulk and Heel Wastes."

The aqueous dissolution behavior of saltcake is being studied through experiments with surrogates and actual saltcake samples. Thermochemical modeling of the dissolution process is being performed using the ESP code. The surrogate results are used to further develop the database in the ESP model and tests with actual wastes are used to validate the surrogates and model predictions. Workscope to complete this task includes

- Complete dissolution tests on selected actual saltcake samples (FY00, FY01).
- Complete benchmarking and validation of ESP code for Hanford saltcake wastes (FY01).

Budget Profile: Saltcake Dissolution
(TFA Technical Response 99054B; Work Package WT-08-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL08WT41	200				
INEEL						
ORR	OR16WT41	75				
SRS						
WVDP						
TFA Total		275	270	TBD	TBD	TBD
ASTD						
CMST						
FETC						
ESP						
International						
Robotics						
University		200	175			
EM-50 Total		475	445	TBD	TBD	TBD

Problem Element Title: 1.2.2.4 Clarify Liquid Stream

Problem Element Description and Priority Site Needs

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. The site need addressed by this problem element is addressed below.

Problem Element: 1.2.2.4 Clarify Liquid Stream				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
OR-TK-05	ORNL Tank Sludge and Supernatant Separations	OR-311	Cross-Flow Filtration	350, 1547, 2096

Technical Tasks

Cross-Flow Filtration (TFA Technical Response 99084; Work Package WT-08-01)
ORR has approximately 180,000 gal of mixed RH-TRU sludge and 800,000 gal of mixed non-TRU supernate stored in underground tanks. The GAAT, OHF, and BVEST waste must be retrieved, consolidated in the MVST, and immobilized to meet transportation and disposal requirements. Solid-liquid separations equipment is required to improve the efficiency of handling secondary wastewater generated during sludge transfer/treatment operations, to minimize the volume of waste that must be treated for disposal, and to maintain solids content in slurries at the desired levels for pipeline transport or for feed to treatment facilities. The previous baseline technology was two-stage settling of the sludges in the storage tanks. This process was slow and did not maintain the required solids content in the feed for treatment processes.

Small-scale, single-element tests with surrogates and selected samples of actual waste indicate that cross-flow filtration should be effective for removing suspended solids from ORR tank waste supernatant liquids. In FY99, a cross-flow filtration unit was successfully deployed at ORR and has been used to filter MVST wastes. Workscope to complete this activity includes

- Evaluate and document the first deployment of the cross-flow filtration system for treating Melton Valley Storage Tank waste (FY00, FY01, EM-30, TFA).

Problem Element Title: 1.2.2.4 Clarify Liquid Stream

Budget Profile: Cross-Flow Filtration (TFA Technical Response 99084; Work Package WT-08-01)						
	TTP#	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Hanford						
INEEL						
ORR						
SRS						
WVDP						
TFA Total		0	100	TBD	TBD	TBD
ASTD	OR08SD10	150	100			
CMST						
FETC						
ESP						
International						
Robotics						
University						
EM-50 Total		150	200	TBD	TBD	TBD

Problem Element Description and Priority Site Needs

Radionuclide removal from tank waste supernate and dissolved wastes is a primary requirement at all the DOE waste tank sites. This is because the presence of radionuclides directly impacts waste immobilization decisions and the volume and cost of low-level and high-level wastes generated. The primary radionuclides of concern are cesium (Cs), strontium (Sr), technetium (Tc), and transuranic elements (TRUs). 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 site needs addressed in this problem element are identified below.

Problem Element: 1.2.2.5 Remove Radionuclides				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
ID-2.1.06	TRU, Cs, and Sr Removal from High Activity Wastes	ID-HLW-103	TRUEX, SREX and Cesium Removal from INEEL Wastes	21, 347, 2096
ID-2.1.28	Cs Removal from Newly Generated Liquid Waste	ID-HLW-103	Cesium Removal Using Crystalline Silicotitianate	21
ID-2.1.53	Cs Removal from High Activity Wastes	ID-HLW-103	TRUEX, SREX and Cesium Removal from INEEL Wastes	21, 347, 2096, 10001
ID-2.1.54	TRU Removal from High Activity Wastes	ID-HLW-103	TRUEX, SREX and Cesium Removal from INEEL Wastes	21, 347, 2096
ID-2.1.55	Sr Removal from High Activity Wastes	ID-HLW-103	TRUEX, SREX and Cesium Removal from INEEL Wastes	21, 347, 2096
ID-2.1.63	Universal Solvent Process for TRU, Cs and Sr Removal	ID-HLW-103	Universal Solvent Process for TRU, Sr, and Cs Removal	21, 347, 410, 841, 2096
OR-TK-11	ORNL Tank Supernatant Pretreatment	OR-311	Modular Evaporator Ion Exchange System	20, 21, 2096
SR99-2034	Second Generation Salt Feed Preparation	SR-HL07	Alternatives to In-Tank Precipitation	21, 2009

Technical Tasks

<u>Transuranic Extraction (TRUEX), Strontium Extraction (SREX), and Cesium Removal from INEEL Wastes</u> (TFA Technical Response 99001; Work Package WT-09-01)
Removal of TRU, Sr, and Cs from high-activity waste is the current baseline treatment option at INEEL. The site is preparing an Environmental Impact Statement (EIS) to evaluate alternatives for radionuclide removal. The removal of TRU and Sr from liquid wastes and dissolved calcine will be accomplished in the TRUEX and SREX solvent extraction processes and Cs removal will be accomplished by ion exchange (the current baseline is ammonium molybdophosphate-polycrylonitrile (AMP-PAN). Prior work has demonstrated the technical merit of the TRUEX, SREX, and AMP-PAN processes on liquid tank waste streams. Additional testing to demonstrate the processes on dissolved calcines is required to

support final technology decisions, and to support flowsheet and process development. Workscope to complete this activity includes

- Demonstrate integrated TRUEX, SREX, and Cs removal flowsheet using hot-cell contactors and simulated waste (or actual tank waste, if available) (FY00, TFA, INEEL).
- Develop process for removal of TRU, Sr, and Cs from dissolved calcine solutions using TRUEX, SREX, and AMP-PAN technologies (FY00, TFA, INEEL).
- Demonstrate TRUEX, SREX, and AMP-PAN flowsheet on actual dissolved Zr-calcine solutions (FY01, TFA, INEEL).
- Demonstrate TRUEX, SREX, and AMP-PAN flowsheet on actual dissolved Al-calcine solutions (FY02, TFA, INEEL).
- The EM Science Program is funding several projects related to radionuclides separations. The TFA is interested in continuing relevant work through the science program and through applied research funding.
  - Continue the development of EMSP and related technologies on solvent extraction processes for the separations of radionuclides.
  - Continue the development of EMSP and related technologies using novel ligands and supports to achieve radionuclide separations.

Budget Profile: TRUEX, SREX and Cesium Removal from INEEL Wastes
(TFA Technical Response 99001; Work Package WT-09-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL	ID70WT32	700				
ORR						
SRS						
WVDP						
TFA Total		700	500	500	TBD	TBD

Universal Solvent Process for TRU, Sr, and Cs Removal (TFA Technical Response 99001 [work formerly described in Technical Response 99041]; Work Package WT-09-01)
The Universal Solvent Extraction Process, a single-step process using multiple extractants for the removal of TRU, Sr, and Cs, has been included in the INEEL HLW EIS as an option for radionuclide separations. Prior work has demonstrated the technical merit of the cobalt dicarbollide plus TRU extractant processes on a liquid tank waste stream. The development of this process has been supported by ESP and is a collaborative development effort with Russia's Khlopin Radium Institute. Additional testing is required to demonstrate the processes on dissolved calcines to support final technology decisions, and to support flowsheet and process development. Workscope to complete this activity includes

- Conduct pilot-scale studies with simulated wastes to determine processing parameters and long-term solvent performance (FY00, INEEL, ESP, Khlopin Radium Institute).
- Develop a process for removal of TRU, Sr, and Cs from dissolved calcine solutions using the universal solvent extraction process (FY00, INEEL, ESP, Khlopin Radium Institute).
- Demonstrate the universal solvent extraction process flowsheet on actual dissolved Zr-calcine solutions (FY01, INEEL, ESP, Khlopin Radium Institute).

- Demonstrate the universal solvent extraction process flowsheet on actual dissolved Al-calcine solutions (FY02, INEEL, ESP, Khlopin Radium Institute).

Budget Profile: Universal Solvent Process for TRU, Sr, and Cs Removal
TFA Technical Response [formerly 99041]; Work Package WT-09-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL						
ORR						
SRS						
WVDP						
TFA Total		0	550	500	TBD	TBD
ASTD						
CMST						
FETC						
ESP	ID76C311	250				
International	Russia	200				
Robotics						
University						
EM-50 Total		450	550	500	TBD	TBD

Alternatives to In-Tank Precipitation (TFA Technical Response 99070; Work Package WT-09-01)
To prepare SRS waste for final disposal, cesium and other soluble transuranic wastes must be separated. The original baseline salt processing step, known as In-Tank Precipitation (ITP), initiated operation in 1995 using tetraphenylborate (TBP). In FY98, DOE decided to abandon the ITP process for removal of Cs because production goals and safety requirements could not be simultaneously met. The site has embarked on a downselection process for a replacement Cs removal technology and selected the Small-Tank Tetraphenylborate Precipitation and Crystalline Silicotitanate (CST) Ion Exchange processes for further evaluation for Cs removal. The TFA has developed technologies for consideration in the downselection process and is providing technical assistance to the process. During FY99, the TFA conducted tests on the TPB and CST processes as well as the monosodium titanate (MST) process that is proposed for removal of uranium, plutonium, and Sr, regardless of the Cs removal technology selection.

Following the final downselection, the TFA will provide technical information necessary to fully implement the selected Cs removal process. That workscope will be defined after the selection. Work activities to support this activity include

- Adapt and deploy a germanium spectrometer to measure Cs-137 and Sr-90 (FY00, CMST, SRS).
- Design, fabricate, and deploy a neutron counting system to calculate total alpha concentration (FY00, CMST, SRS).
- Determine rate and equilibrium loading of TRU and Sr on MST to support process selection and flowsheet and process design (FY00, TFA, SRS).

- Demonstrate cross-flow filtration for monosodium titanate TRU/Sr removal process (FY00, TFA, SRS).
- Determine physical properties of sorbents and variability from lot to lot (FY00, ASTD, SRS).
- Remaining workscope will be defined based on downselection decisions.

Budget Profile: Alternatives to In-Tank Precipitation
(TFA Technical Response 99070; Work Package WT-09-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL09WT32	650				
INEEL						
ORR						
SRS	SR19WT31	3000				
WVDP						
TFA Total		3650	6200	5200	TBD	TBD
ASTD	OR08SD11	3550				
CMST	RL30C211	300	200	200		
FETC						
ESP	SR16C342	250	200	200		
International						
Robotics						
University						
EM-50 Total		7750	6600	5600	TBD	TBD

<u>Modular Evaporator Ion Exchange System</u> (TFA Technical Response 99086; Work Package WT-09-01)
ORR has approximately 800,000 gallons of mixed, non-TRU supernate stored in underground tanks. Increasing levels of Cs in the wastes from new research activities and concentration of legacy wastes requires that the Cs be removed before solidification. An integrated CST ion exchange system and evaporator was deployed in FY99 at ORR and is processing the supernates. Workscope to complete this activity includes

- Continue operation of modular evaporator ion exchange system to process ORR supernates (FY00, FY01, ASTD, ORR).
- Document performance of modular evaporator ion exchange system at ORR (FY00, FY01, ASTD, ORR).

Budget Profile: Modular Evaporator Ion Exchange System (TFA Technical Response 99086; Work Package WT-09-01)						
	TTP#	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Hanford						
INEEL						
ORR						
SRS						
WVDP						
TFA Total		0	0	TBD	TBD	TBD
ASTD	OR08SD11	910	310			
CMST						
FETC						
ESP						
International						
Robotics						
University						
EM-50 Total		910	310	TBD	TBD	TBD

Cesium Removal Using Crystalline Silicotitanate (CST)

INEEL plans to use CST for Cs removal from newly generated wastes. These wastes may be partially neutralized before removal. Data on the use of CSTs with newly generated wastes is needed to support design. Prior work has demonstrated the technical merit of CST on highly alkaline (pH 10-14) and highly acidic (1-2 M HNO_3) wastes. However, no development work has been performed on partially neutralized (pH 2-4) wastes. Workscope to complete this activity includes

- Determine the extent of neutralization required to meet storage requirements (see Problem Element 1.2.3.1, "Process LLW").
- Determine sorption chemistry of INEEL neutralized wastes on CST.

Problem Element Title: 1.2.2.6 Integrate Pretreatment and Immobilization Technology Systems

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Problem Element Description and Priority Site Needs

Pretreatment and immobilization systems are intimately related because the chemistry and performance requirements of one directly impacts the other system. This problem element provides the understanding and tools necessary to integrate the pretreatment and immobilization processes.

Problem Element: 1.2.2.6 Integrate Pretreatment and Immobilization Technology Systems				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
ID-2.1.24	Integration/Optimization of High Activity/Low Activity Waste Process Flowsheet	ID-HLW-103	Integration/Optimization of High Activity/Low Activity Waste Process Flowsheet	

Technical Tasks

Integration/Optimization of High-Activity/Low-Activity Waste Process Flowsheet (TFA Technical Response 99009; Work Package WT-06-01)
Many alternatives and options are being considered for the treatment and qualification of radioactive wastes located at INTEC for permanent disposal. Adequate evaluation of these options requires that each one have a process flow diagram and associated mass and energy balances. The flowsheet provides the technical basis for performing process definition cost estimates, safety evaluations, and estimates of impact to the environment. Later, they provide the technical bases for facility design and operating permit applications. Presently, the flowsheet calculations are performed manually or with the assistance of several different software tools. The existing flowsheet development tools, both mathematical models and software, need to be integrated into a single simulation model to perform these calculations automatically, with minimal effort on the part of the engineer(s) who are tasked with doing this work. This integrated model will provide more process performance information required for further evaluations. Workscope to complete this activity include

- Complete the software QA Plan, Software Requirements Specification, Process Options Description, and Software Design Document (FY00, FY01, TFA, INEEL).
- Complete integrated steady-state flowsheet for selected processing option (FY01, TFA, INEEL).
- Update the Software Requirements Specification, Process Options Description, and Software Design Document to include downselected process option and dynamic process simulation (FY02, TFA, INEEL).
- Complete dynamic integrated flowsheets and update steady-state integrated process flowsheets (FY02, FY03, TFA, INEEL).

Problem Element Title: 1.2.2.6 Integrate Pretreatment and Immobilization Technology Systems

Budget Profile: Integration/Optimization of High Activity/Low Activity Waste Process Flowsheet (TFA Technical Response 99009; Work Package WT-06-01)

	TTP#	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Hanford						
INEEL	ID77WT31	150				
ORR						
SRS	SR16WT31	150				
WVDP						
TFA Total		300	300	TBD	TBD	TBD

Problem Element Description and Priority Site Needs

Retrieved sludge from tank waste requires processing to remove entrained radionuclides for downstream separation and processing, and to remove salts and minerals that may impact downstream vitrification. Sludges at SRS, Hanford, and ORR will require processing to remove nonradioactive constituents that either add to the volume of the resulting HLW (e.g., aluminum) or impact immobilization processing (e.g., chromium, technetium, or phosphate). Processing of sludges primarily involves washing and separations. The site needs addressed in this problem element are identified below.

Problem Element: 1.2.2.7 Process Sludge				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
RL-WT024	Enhanced Sludge Washing Process Data	RL-TW05	Enhanced Sludge Washing Process Data and Chromium Removal	233, 2096, 2236

Technical Tasks

Enhanced Sludge Washing Process Data (TFA Technical Response 99055A; Work Package WT-11-01, unfunded)

The current baseline pretreatment option for Hanford tank sludges is enhanced sludge washing (ESW) -- 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 during development of the process flowsheet. Process data on ESW are needed to support the SST retrieval sequence analysis, which provides the foundation for Hanford's Phase II RFP and contract award. Additional data on the effect of varying temperature and caustic concentration on leach performance is important. In FY98, TFA-supported data was used as the basis for the Hanford Federal Facility Agreement and Consent Order milestone (M-50-03) decision that ESW results in a reasonable number of HLW canisters.

Work activities to address baseline ESW performance as a function of temperature and caustic concentration will include

- Complete parametric tests of caustic leaching with two to four additional Hanford sludges to support SST retrieval sequence analysis.
- Expand existing database for use with ESP code and validate code.

Chromium Removal (TFA Technical Response 99055A, Work Package WT-11-01, unfunded)

REDOX-type sludges at Hanford contain most of the hard to remove Cr and require additional testing to confirm Cr removal efficiencies during ESW and to reduce uncertainties in extrapolating data from single tanks to groups of tanks. Completion of this work supports retrieval sequence development and broadens the technical foundation needed to proceed with Phase II at Hanford.

Work activities to support resolution of Hanford's Cr removal issues include

- Conduct laboratory-scale development of enhanced processes to remove Cr from Hanford sludges.
- Conduct bench-scale testing of selected processes to enhance removal of Cr from sludges.
- Continue EMSP and related research studies on the chemistry and speciation of chromium in waste tank storage environments.

Problem Element Description and Priority Site Needs

The low-level waste (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 onsite to off-site disposal. The site needs addressed in this problem element are identified below.

Problem Element: 1.2.3.1 Process LLW				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
ID-2.1.23	Low-Activity Wasteform Qualification	ID-HLW-103	Conditioning and Immobilization of Low-Activity Waste	21, 82, 2094, 2371
ID-2.1.28	Cs Removal from Newly Generated Liquid Waste	ID-HLW-103	Conditioning and Immobilization of Low-Activity Waste	21, 82, 2094, 2371
ID-2.1.35	Direct Immobilization of INTEC Sodium-Bearing Waste	ID-HLW-103	Conditioning and Immobilization of Low-Activity Waste	21, 82, 2094, 2371
ID-2.1.38	Conditiong of Low Activity Wastes for Treatment	ID-HLW-103	Conditioning and Immobilization of Low-Activity Waste	21, 82, 2094, 2371
ID-2.1.40	Low Activity Waste Grout Sorbent Addition to Reduce Leachability	ID-HLW-103	Conditioning and Immobilization of Low-Activity Waste	21, 82, 2094, 2371
OR-TK-06	Tank Sludge Supernatant Immobilization	OR-311	Conditioning and Immobilization of Low-Activity Waste	21, 82, 2094, 2371

Technical Tasks

(TFA Technical Response 99019; Work Package WT-07-01)
The current baseline for LLW immobilization at SRS, ORR, INEEL is grouting. The baseline for Hanford is being established based on performance requirements set forth in the Tank Waste Remediation System (TWRS) privatization contract. Glass waste forms are being considered for Hanford and have been used for M Area sludges at SRS. At INEEL, high nitrate levels in LLW feed require development of an appropriate LLW grout formulation and/or denitration process to pretreat the LLW feed. At ORR and INEEL, work is needed to identify sorbents and stabilizers that will serve as binders or additives for retaining hazardous constituents and radionuclides in order to enhance the performance of the waste form. A sound basis for selecting LLW forms and the data needed to make this selection would help DOE evaluate privatization proposals, support design decisions, and provide stakeholders with better information for considering waste form options.

In FY98 and FY99, denitration process evaluations were completed and INEEL prepared a report recommending thermal denitration as the baseline. AEAT and INEEL, under a jointly funded EM-50 and EM-30 development effort, prepared several grout formulations. This work provided candidate grout formulations for denitration and direct grouting of the LAW fractions. Workscope to complete this activity includes

- Development and testing of thermal denitration for LAW.
  - Evaluate potential for volume reduction and cost savings through engineering analyses (FY00, INEEL, TFA).
  - Define and conduct testing necessary to support design (FY01, INEEL, TFA).
  - Conduct small-scale demonstration of denitration process and subsequent waste immobilization by grouting (FY02, INEEL, TFA).
- Evaluate sorbents and stabilizers to enhance performance of low-activity waste forms for INEEL and ORNL.
  - Identify requirements and potential sorbents and stabilizers, including silica gel (FY00, TFA, ORNL, INEEL).
  - Conduct non-radioactive testing of potential sorbents and stabilizers (FY00, TFA, ORNL, INEEL, Russia).
  - Conduct radioactive testing of potential sorbents and stabilizers using actual INEEL and ORR wastes (FY01, TFA, ORNL, INEEL).
  - Document identification and evaluation of sorbents and stabilizers to enhance performance of low-activity waste forms (FY02, TFA, ORNL, INEEL).
- Develop grout formulation for immobilizing INEEL LAW.
  - Evaluate need for pretreating INEEL wastes prior to grouting (FY00, INEEL, TFA).
  - Develop grout formulation for INEEL LAW and demonstrate that the resulting product meets specifications (FY00, INEEL, TFA, AEAT).
  - Procure grouting equipment and services (FY00, INEEL, TFA, AEAT).
  - Demonstrate grouting of INEEL Type 2 wastes (FY01, FY02, INEEL, TFA).
  - Document demonstration of grouting INEEL wastes (FY02, INEEL, TFA).
- Issue technical baseline for newly-generated liquid waste flowsheet (FY00, INEEL, TFA)

Budget Profile: Conditioning and Immobilization of Low-Activity Waste (TFA Technical Response 99019; Work Package WT-07-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL	ID77WT31	1050				
ORR	OR10WT31	275				
SRS	SR16WT31	50				
WVDP						
TFA Total		1375	1080	750	TBD	TBD
ASTD						
CMST						
FETC						
ESP						
International	AEAT HQ06T222	200 50	150 50	50 0		
Robotics						
University						
EM-50 Total		1625	1280	800	TBD	TBD

Problem Element Title: 1.2.3.2 Process HLW

Problem Element Description and Priority Site Needs

Immobilization of the HLW streams INEEL, SRS, and Hanford is required to produce an acceptable HLW form for final disposal. Calcine immobilization and vitrification are the baseline methods for HLW immobilization. In addition to these baseline processes, this problem element addresses melter feed preparation, process monitoring, and process control methods to produce acceptable waste forms.

At all of the DOE tank sites, the baseline technology for HLW processing is vitrification (this process is operational at SRS and WVDP). At SRS, methods that can reduce the cost of operations are being identified and evaluated. Cost reduction can occur through optimization of waste loading that reduces the number of glass canisters produced, and improvements in process equipment and materials of construction that reduce maintenance and downtime by reducing corrosion or other material failure problems. At the Hanford Site, optimized waste loading and melter selection are considerations for developing the baseline to support Phase II privatization, especially with regard to concerns about high Cr wastes and their compatibility with current melter designs and waste formulations. At INEEL, waste formulations for sodium-bearing waste and calcined wastes followed by melter testing is needed to meet an accelerated schedule for the record of decision (ROD) and the FY00 Title 1 design schedule. Corrosion of melter materials from acidic wastes at the INEEL is a key issue that must be addressed with both waste formulation and materials development and testing. The site needs addressed in this problem element are identified below.

Problem Element: 1.2.3.2 Process HLW

STCG Need Number	Need Title	PBS Number	Technical Task	OST Number
ID-2.1.57	Conditioning of HAW for Treatment	ID-HLW-103	Improve Waste Loading and HLW Glass	2009, 2092
ID-2.1.58	HAW Immobilization	ID-HLW-103	Improve Performance and Design of HLW Melters	2009, 2092
RL-WT06	Identification and Management of Problem Constituents for HLW Vitrification	RL-TW05	Improve Waste Loading and HLW Glass	2009
SR99-2032	Optimize Melter Glass Chemistry	SR-HL05	Improve Waste Loading and HLW Glass	2009
SR99-2036	Develop Second Generation DWPF Melter	SR-HL05	Improve Performance and Design of HLW Melters	2009, 2092

Technical Tasks

Improve Waste Loading and HLW Glass (TFA Technical Response 99073; Work Package WT-06-01)

The DWPF at SRS complies with Waste Acceptance Product Specifications (WAPS) and process control requirements by demonstrating, to a high confidence, that melter feed will produce glass that meets all quality and processing requirements. This method requires that uncertainties associated with sampling, sample analysis, and models used to estimate properties are determined, and that sufficient allowance is made for these uncertainties when controlling feed composition.

The existing model for liquidus temperature has a large uncertainty associated with it, leading to a reduction in allowable waste loading. Constraints on the application of the durability model can cause acceptable glasses to be rejected because the durability is indeterminate (i.e., the applicability of the model is not certain). New or improved versions of existing property models for liquidus temperature and durability are needed, and model tolerances need to be identified. These models should be applicable to the entire range of plausible glass compositions.

In addition to liquidus issues at SRS, waste loading issues associated with Cr and glass phase separation have been identified at Hanford and SRS. Currently, HLW glasses are formulated to ensure that little or no insoluble phases exist in the HLW melter. Insoluble phases are caused by such problem constituents as chrome minerals, spinels, and noble metals (e.g., Ru, Rh, Pd). An alternative method for handling problem constituents in HLW glasses is needed. The volume of HLW glass that will be produced from the Hanford sludges depends on the ability to solubilize or dilute problem constituents that make up a very small fraction of the overall waste. Minimizing the impact of the problem constituents is important for formulating a staging strategy and staging the wastes to be treated during the Phase II privatization effort. Diluting the problem constituents usually involves blending of waste types and/or increasing the volume of glass waste forms. Both of these alternatives are expensive. An alternative for handling problem constituents is to allow them to remain insoluble in the glass matrix. This approach is acceptable as long as the insoluble phase does not adversely affect the processing of the waste or the quality of the waste form. Usually, the concentration of the insoluble constituents in the final waste form would be very low (less than 2%). Information is needed on the technical viability of producing HLW glasses with insoluble phases.

INEEL is developing a vitrification process for the immobilization of INTEC/INEEL HLW. As part of that development, there is a need to determine glass-forming additives required to vitrify the HLW to a form that has physically and chemically acceptable properties for storage and disposal. An important input to both process selection and cost evaluation is achievable waste loading. This information will be used in the design of the vitrification process, including the processes to ensure the quality of the final glass waste form.

Work activities to support needs for optimizing waste loading will include

- Development of liquidus, nepheline, spinel, and waste loading maximization data to support increased waste loading at SRS and Hanford.
  - Investigate spinel and nepheline formation and multi-phase glasses and resulting impacts on HLW vitrification and durability of HLW glasses (FY00, FY01, FY02, TFA, EM-30).
  - Issue technical report on glass liquidus temperature (FY00, TFA, EM-30).
  - Issue technical report on small-scale melter run to validate liquidus temperature data and DWPF model improvement (FY00, TFA, EM-30).
  - Complete liquidus temperature studies (FY01, TFA, EM-30).
  - Complete evaluation of nepheline formation in HLW glasses (FY02, TFA, EM-30).

  - Complete development of data to improve DWPF process control models (FY02, TFA, EM-30).
- Develop Acceptable Glass Formulation for INEEL HAW
  - Issue technical report recommending INEEL glass composition for demonstration in scaled melter (FY00, TFA, EM-30).
  - Issue technical report on small-scale melter run to demonstrate current INEEL vitrification flowsheet (FY00, TFA, EM-30).
  - Evaluate glass compositions based on proposed pretreatment processes for INEEL wastes (FY01, FY02, TFA, EM-30).
- The EMSP is funding several projects related to waste glass chemistry and glass melting. The TFA is interested in continuing relevant work through the science program.
  - Continue EMSP and related research studies on the kinetics and thermodynamics of phase separation and crystallization in radioactive waste glasses.
  - Continue EMSP and related research studies for developing and implementing sensors for monitoring waste glass melting processes.

Budget Profile: Improve Waste Loading and HLW Glass
(TFA Technical Response 99073; Work Package WT-06-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL37WT31	630				
INEEL	ID77WT31	300				
ORR						
SRS	SR16WT31	670				
WVDP						
TFA Total		1600	1900	1400	TBD	TBD

<u>Improve Performance and Design of HLW Melters</u> (TFA Technical Response 99068; Work Package WT-06-01)
SRS's DWPF has been operating for a number of years, allowing the identification of opportunities to improve the vitrification process design and to improve the glass melter design. INEEL is currently developing the processes for vitrification of their HLW. The work described here will provide the process and melter improvements for DWPF and support the development of INEEL vitrification process and melter.

The glass melter is one of the most expensive and most complicated components in DWPF. Because of lower than anticipated melting rates and poor glass pouring performance, the melter has been the production rate limiting component in the plant. Although DWPF Melter-1 has exceeded its two-year design life expectancy, it is desirable to evaluate/improve its design life and performance by improving the pour spout and heater systems, and by developing enhancements to address processing of future feeds containing higher levels of noble metals. Accumulation of noble metals has been demonstrated to shorten the life of HLW glass melters in this country, as well as in Europe.

Changes to the configuration of the melter pour spout are required to stabilize glass pouring behavior. A phenomenon called "wicking" causes the glass to adhere to the wall of the pour spout rather than dropping directly into the canister. This has resulted in significant plugging of the pour spout and poor glass production rates versus design. Current work is focused on the DWPF pouring issues related to pour spout configuration (knife edges, heater locations, temperature, etc.) to prevent the occurrence of wicking.

Melter feed chemistry is affected by feed conditioning (for DWPF: level of washing, composition of the Cs bearing stream, levels of carbonate in-growth to the sludge, and the extent of REDOX adjustment that occurs in feed preparation; for INEEL: the extent of denitration occurring in pretreatment, chemical components added during pretreatment, high Zr and other components that may be difficult to incorporate into the glass). Improvements in the feed chemistry (REDOX potential) can impact melting behavior and improve melt rates. This part of the need relates to both SRS and to INEEL and will be addressed jointly. At INEEL, conditioning of the HAW fraction of treated calcine is needed to reduce glass volume for expected interim storage/transportation and to regulate the redox potential of the feed to the melter. Highly oxidized feeds such as INEEL's tends to foam in the melter and can result in operating problems similar to those being experienced at SRS. HAW immobilization requires pilot-scale operation of proposed feed streams for melt rate, compatibility, and general operability tests.

Work activities to support SRS and INEEL needs in melter throughput and design include

- Develop improved melter pour spout for DWPF. Work to understand DWPF pour stream wicking was initiated in FY98: fundamental study of pour wicking was initiated and experimental test equipment, including a full-scale pour test unit, were installed and testing initiated. Workscope to complete this activity includes
    - Issue report on design recommendations for melter pour spout and riser heaters (FY00, TFA, SRS, University Programs).
- Test Melter Design Enhancements
    - Test design concepts incorporating recommendations from review of commercial and international melter technology and proposed methods to address noble metal settling (FY00, FY01, SRS, TFA).
    - Provide design input and requirements for DWPF second generation melter (FY01, FY02, SRS, TFA).
- Melter Feed Chemistry Enhancements
    - Evaluate impacts of REDOX and application of reductants on INEEL glass formulation quality, melter off gas, and materials corrosion (FY00, FY01, INEEL, SRS, TFA).
    - Recommend control of REDOX and anion concentration to improve melting process (FY01, FY02, INEEL, SRS, TFA).

Budget Profile: Improve Performance and Design of HLW Melters (TFA Technical Response 99068; Work Package WT-06-01)						
	TTP#	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Hanford	RL37WT31	125				
INEEL	ID77WT31	250				
ORR						
SRS	SR16WT31	975				
WVDP						
TFA Total		1350	1425	1300	TBD	TBD
ASTD						
CMST						
FETC						
ESP						
International						
Robotics						
University	RL09WT31	125	100			
EM-50 Total		1475	1525	1300	TBD	TBD

Problem Element Description and Priority Site Needs

Closure of radioactive waste tanks requires sampling and/or characterization of waste tank residuals, definition of and compliance with closure criteria (i.e., "how clean is clean?"), and stabilization of the tank (potentially including barrier technology). Stabilization of the tanks and installation of surface or subsurface barriers may be required following retrieval and post-retrieval characterization. This will 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 may include filling the tank with grout and stabilizing wastes, or a 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.

Closure of radioactive waste tanks is a key element in the tank sites' baseline plans for reducing mortgage and accelerating cleanup SRS has closed two HLW tanks and will conduct a treatability study in FY00 for closing its Old Burial Ground Tanks. ORR is preparing for future GAAT tank closures through the GAAT treatability study and will be closing its Old Hydrofracture Tanks in FY00. INEEL is actively working toward meeting an Idaho milestone to close two of its tanks in FY03. The site needs addressed in this problem element are identified below.

Problem Element: 1.3.1 Close Tanks				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
ID-2.1.39	Acceptance Criteria for LAW Disposal in Underground Storage Tanks	ID-HLW-103	Idaho Tank WM-182 Closure Demonstration	22, 82, 2094, 2368
ID-2.1.42	Acceptance Criteria for Tank Closure	ID-HLW-105	Idaho Tank WM-182 Closure Demonstration	22, 82, 2094, 2368
ID-2.1.45	Acceptance Criteria for Grouting Tank Heels	ID-HLW-103	Idaho Tank WM-182 Closure Demonstration	22, 82, 2094, 2368
ID-2.1.46	Management of Tank Heel Liquids	ID-HLW-105	Idaho Tank WM-182 Closure Demonstration	22, 82, 2094, 2368
ID-2.1.47	Management of Tank Heel Solids	ID-HWI-105	Idaho Tank WM-182 Closure Demonstration	22, 82, 2094, 2368
ID-2.1.48	Wasteform Qualification for Low-Activity Waste in Underground Storage Tanks	Id-HLW-103	Idaho Tank WM-182 Closure Demonstration	22, 82, 2094, 2368
ID-2.1.62	Acceptance Criteria for Bin Set Closure	ID-HLW-103	Idaho Tank WM-182 Closure Demonstration	22, 82, 2094, 2368
OR-TK-09	ORNL Tank Closure	OR-321 OR-322	Demonstration of Grout Injection Technology for Tank Closure	22, 2368

Problem Element: 1.3.1 Close Tanks				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
RL-WT061	Reactive Barriers to Contaminant Migration	RL-TW04	Sequestering of Radionuclide Contaminant Migration	82
SR99-2051	Technology to Mitigate Effects of Technetium Under Tank Closure Conditions	SR-HL03	Sequestering of Radionuclide Contaminant Migration Leaching and Treatment of Tc For Tank Closure	82, 233
SR99-3022	In Situ Grouting of Underground Tanks (Formerly Used for the Storage of Radioactive Solvents)	SR-ER02	Demonstration of Grout Injection Technology for Tank Closure	22, 2368
OH-WV-904	High Level Waste Tank Closure	OH-WV-02	Demonstration of Grout Injection Technology for Tank Closure	22, 2368

Technical Tasks

Demonstration of Grout Injection Technology for Tank Closure (TFA Technical Response 99085; Work Package WT-05-01)

ORR, SRS, WVDP, and other DOE facilities have waste storage tanks that will require either complete removal or in-place stabilization of sludge heels remaining after retrieval operations. In many cases, complete removal of the heels can be extremely costly with negligible resulting benefits to health or to the environment. Residual contamination in the tank walls and liners may also dictate tank closure. An in-situ grouting process is under development to stabilize and close tanks with small amounts of residual heels and contamination. A multi-point, high-pressure grout injection technology was demonstrated on a cold basis in FY98 and again in FY99. This technology can accommodate the varying sizes and configurations of waste tanks across the DOE complex. Activities to complete this work include

- Complete hot deployment of the MPI® grout injection/mixing technology in an ORR limited-access, small horizontal (OHF) tank (FY00, EM-40, TFA).
- Document performance of grout injection/mixing technology in OHF tank (FY00, EM-40, TFA).
- Depending on the Feasibility Study results, complete hot deployment of the MPI® grout injection/mixing technology in an ORR mid-sized, vertical (TH-4) tank (FY01, EM-40, TFA).
- Document performance of grout injection/mixing technology in TH-4 tank (FY01, EM-40, TFA).
- Complete demonstration of innovative grout injection/mixing technology for a SRS Old Burial Ground (OBG) tank (FY00, EM-40, TFA).
- Document performance of innovative grout injection/mixing technology for a SRS OBG tank (FY00, EM-40, TFA).

Budget Profile: Demonstration of Grout Injection for Tank Closure (TFA Technical Response 99085; Work Package WT-05-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL						
ORR	OR16WT51	750				
SRS	SR16WT51	600				
TFA Total		1350	500	TBD	TBD	TBD

Idaho Tank WM-182 Closure Demonstration (TFA Technical Response 99023; Work Package WT-05-01)
The INTEC at INEEL has 11 tanks that contain approximately 1.7 million gallons of radioactive liquid waste. A closure plan must be submitted to the Idaho Department of Environmental Quality by December 31, 2000. Moreover, two of the tanks, WM-182 and WM-183, are scheduled for early closure by 2003. Tank WM-182 contains substantial internal piping in the bottom of the tank. Closure of this tank in 2003 will represent the first closure demonstration within the DOE complex of a tank containing a substantial amount of tank-floor, internal cooling system piping. Lessons learned from the INEEL WM-182 tank closure will be directly applicable to similar piping challenges facing WVDP and SRS. In addition, Tank WM-182 contains acidic waste liquid heels that contain some solids, both suspended and settled. Grouting these heels (after possible treatment) in place is a possible tank closure strategy. (A Record of Decision scheduled for December 1999 will determine the tank closure strategy.) Moreover, the site has LAW that it is considering grouting and pumping to existing underground storage tanks for permanent disposal on site. Waste form acceptance criteria must be developed and approved to use tanks as a low-level Class A waste disposal facility.

Finally, INEEL has requested help in establishing acceptance criteria for closure of its bin sets. These bin sets contain granular solids and powder called calcine that are generated when liquid waste from its tanks are processed in the New Waste Calcining Facility. Similar to WM-182 tank closure, bin set closure will consider RCRA requirements, NRC requirements, DOE Orders, and the Settlement Agreement. Bin set closure is also similar to any tank closure in the sense that the goal is to minimize the risk of releasing hazardous or radioactive material to the environment.

During FY99, INEEL completed a tank bottom mockup of Tank WM-182 for grout testing. The goal of this test was to determine the extent of impacts that internal piping near the floor of the tank has on the grout pouring, mixing, and setup. The results were very promising, and effective grout pour strategies were developed based on the mockup test. Sampling and analysis of WM-182 contents is ongoing to support grout formulation development efforts, as well as definition of closure acceptance criteria.

During FY00-FY02, the TFA will continue to support INEEL's Tank WM-182 Closure Demonstration by developing tank closure criteria and developing and demonstrating grout formulations for tank closure. Workscope to complete this activity includes

- Prepare tank closure plan that discusses tank closure acceptance criteria and their technical bases (FY00, TFA, INEEL).
- Develop grout formulation for stabilizing WM-182 tank heels (FY01, TFA, INEEL).
- Demonstrate grouting of surrogate tank heels in a tank bottom mockup (FY01, TFA, INEEL).
- Complete of cold-demonstration test of tank cleaning/heel treatment process (FY02. INEEL, TFA).
- Document results of tank-cleaning/heel-treatment cold demonstration (FY02, INEEL, TFA).

Budget Profile: Idaho Tank WM-182 Closure Demonstration
(TFA Technical Response 99023; Work Package WT-05-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL	ID77WT23	600				
ORR						
SRS						
WVDP						
TFA Total		600	800	800	TBD	TBD

<u>Leaching and Treatment of Technetium (Tc) for Tank Closure</u> (TFA Technical Response 99088B; Work Package WT-05-01)
SRS and Hanford have identified a need to better understand the chemistry of Tc under the conditions of waste removal and after tank closure. SRS has identified a need to provide credible estimates of the Tc inventory in tank heels in order to determine if the tank can be closed. At a September 1998 Tc workshop conducted at Hanford, needs were identified for more accurate and more complete technetium characterization methods, more accurate inventory estimates for both soluble and insoluble Tc species in the Hanford tank wastes, and establishing non-pertechnetate Tc species removal pretreatment options. Workscope to address these needs includes

- Determine chemical characteristics of Tc in sludges (FY00, ESP).
- Evaluate Tc treatment and removal alternatives (FY00, FY01, ESP).
- Pursue relevant Tc chemistry work through the EMSP. EMSP is funding several related projects.
  - Continue EMSP and related research studies on the chemistry and speciation of technetium in waste tank storage environments.
  - Continue EMSP and related studies on processes for the reduction of the technetium oxidation state and other methods for chemical separation and enhanced immobilization of technetium.

Budget Profile: Leaching and Treatment of Tc for Tank Closure
(TFA Technical Response 99088B; Work Package WT-05-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford						
INEEL						
ORR						
SRS						
WVDP						
TFA Total		0	TBD	TBD	TBD	TBD
ASTD						
CMST						
FETC						
ESP	RL00C311	375	300			
International						
Robotics						
University						
EM-50 Total		375	300	TBD	TBD	TBD

<u>Sequestering of Radionuclide Contaminant Migration</u> (TFA Technical Response 99060; Work Package WT-05-01, unfunded)
Sequestering agents can be used to attenuate the migration of key radionuclides from closed tanks, from previous tank leaks to the soil column, and from LLW disposal facilities. Tc-99 is the primary dose contributor in risk/performance assessments. Its mobility can also be reduced by creating a reducing environment. Hanford has not made any decisions regarding the addition of sequestering agents to tank farm soils, but is interested in further development of the technology as input to its planned NEPA process for closure. SRS used reducing grout to close its first two tanks and is interested in better understanding the range of the reducing zone beneath their tanks. This would allow for less conservative modeling that may lead to lower projected doses to the public from Tc-99 or reduced costs for waste removal.

To address these needs, the TFA will 1) estimate the extent of the reducing zone beneath a tank containing reducing grout, 2) evaluate 3M's EMPORE™ Tc-sequestering membrane technology for LLW disposal facility applications, and 3) test the durability and irreversability of Hanford's candidate getter materials. Workscope to complete these activities includes

- Perform calculations and modeling to estimate the extent and duration of reducing zones beneath tanks closed with reducing grouts.
- Conduct experiments to provide data to support modeling and validation of modeling of the extent of the reducing zone.
- Conduct laboratory tests to determine the durability and reversability of Hanford-identified getters for Tc-99, Se-79, and uranium.
- Conduct field tests on selected getter materials.
- Evaluate 3M's EMPORE™ Tc-sequestering membrane technology for LLW disposal facility applications.

Problem Element Description and Priority Site Needs

The immobilized low-activity or low-level waste (ILAW) from grouting operations at SRS, ORR, and possibly INEEL, and vitrification operations at Hanford will require, in most cases, onsite disposal. Regardless of the specific waste form selected by the site for use, process monitoring and/or product assessment is required to ensure the waste form meets disposal requirements. In addition, LLW disposal will require a performance assessment (see related discussion in problem element 1.3.1, "Close Tanks") and consideration of surface and subsurface engineered barriers to ensure the immobilized LLW disposal site meets performance requirements. 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.

This problem element addresses both ILAW product performance testing and ILAW disposal facility engineering. Needs exist for product acceptance testing to ensure the LLW immobilization process produces an acceptable waste form, data collection to support performance assessment efforts, and evaluation of disposal site barrier technologies to ensure the final disposal of the ILAW meets requirements. The following needs are addressed in this problem element.

Problem Element: 1.3.2 Dispose of LLW

STCG Need Number	Need Title	PBS Number	Technical Task	OST Number
RL-WT-015	Standard Method for Determining Waste Form Release Rate	RL-TW09	Testing and Prediction of Long Term Waste Glass Performance	82, 2094
RL-WT016	Glass Monolith Surface Area	RL-TW09	Glass Monolith Surface Area	82, 2094
RL-WT017	Long-Term Testing of Surface Barrier	RL-TW09	Surface Barrier Testing	10, 523
RL-WT018	Testing of Sand-Gravel Capillary Barrier	RL-TW09	Surface Barrier Testing	10, 523
RL-WT029	Data and Tools for Performance Assessments (Tools)	RL-TW09		82
RL-WT066	Compositional Dependence of the Long Term Performance of Glass as a Low-Activity Waste Form	RL-TW09	Testing and Prediction of Long Term Waste Glass Performance	82, 2094

Technical Tasks

<u>Testing and Prediction of Long Term Waste Glass Performance</u> (TFA Technical Response 99048; Work Package WT-07-01)

Hanford plans to dispose of its LAW as a glass waste form in a near-surface disposal facility. The glass performance must be linked to the disposal facility to provide a valid performance assessment of the ILAW disposal system. A short-term test or suite of tests for evaluation of Hanford ILAW waste forms with respect to long-term performance is needed to provide a technical basis for the performance assessment and to provide a foundation for Hanford's Phase II ILAW product specifications.

To provide a technical basis for accepting ILAW and IHLW, glass composition regions that yield waste forms meeting the specifications of the privatization contract must be identified and documented. The information will provide 1) an independent verification of the results of the private contractor's waste form qualification activities, and 2) a tool to accept actual ILAW and IHLW based on measured and reported compositions.

This task will result in 1) an evaluation of a suite of tests and their relative importance and linkage to the performance assessment and long-term glass performance modeling; and 2) a bounding or qualified composition region with a high confidence of satisfying the long-term performance requirements. Workscope to complete these activities include

- Conduct glass durability tests on selected ILAW glasses to determine long-term durability behavior (FY00-FY04, TFA, Hanford).
- Test ILAW glass formulations to define acceptable glass composition region for Hanford ILAW (FY00-FY02, TFA, Hanford).
- Document a recommended acceptable glass composition region (FY00-FY02, TFA, Hanford).
- Pursue relevant long-term glass performance work through the EMSP. EMSP is funding several related projects.
- Continue EMSP and related research studies on the fundamental mechanisms of the release of chemicals and radionuclides from glass waste forms as input to 1) the development of models describing the performance of glass waste forms in disposal environments and 2) improved glass formulations for LAW and HLW immobilization.

Budget Profile: Testing and Prediction of Long Term Waste Glass Performance
(TFA Technical Response 99048; Work Package WT-07-01)

	TTP#	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Hanford	RL37WT31	600				
INEEL						
ORR						
SRS	SR16WT31	600				
WVDP						
TFA Total		1200	800	600	TBD	TBD

Glass Monolith Surface Area (TFA Technical Response 99049; Work Package WT-10-01, unfunded)
A method is needed to estimate the surface area of vitrified LAW. Performance assessment analyses of LLW disposal systems must estimate the source term from the disposal system. The source term is related to the surface area of the waste form that can be reached by moisture moving through the disposal system. To support performance assessment analyses of Hanford's ILAW disposal system, the following information regarding waste form cracking within a waste package is needed: 1) crack patterns, fines generation, and surface area of the glass waste form, 2) glass surface area reachable by moisture, 3) unsaturated hydraulic properties of the cracked glass, and 4) the impact of aging on these properties. Workscope to complete this activity includes

- Determine important variables that affect glass cracking and surface area.
- Characterize glass cracking in small-scale containers and prototypical ILAW glass packages.

- Evaluate non-intrusive methods for estimating the extent of cracking.

Surface Barrier Testing (TFA Technical Response 99050; Work Package WT-12-01, unfunded)
An integral consideration in disposal of ILAW is the benefits and/or requirements for permeable or impermeable surface and subsurface barriers. Water is the driving force behind releasing contaminants from waste forms and then carrying those contaminants to ground-water. At Hanford, barrier technology can reduce contaminant migration through limiting moisture flow, or in the case of engineered permeable barriers, even retard specific contaminants through the use of special "sorbents" in the barrier construction. Evaluation of the performance of surface barriers, capillary barriers, and the potential use of sorbents or "getter" materials is needed.

- Surface Barriers: Surface barriers are being used over many Hanford environmental restoration and waste management sites and more barriers are expected in the future. Such barriers are used to reduce moisture infiltration and plant and animal intrusion.

- Short-term testing of barriers has occurred under project-sponsored activities, but long-term studies have yet to be conducted. Because the design life of the barrier is 1,000 years, data is needed on long-term barrier degradation to better understand the validity of the design life estimate.

- Capillary Barriers: A sand-gravel capillary barrier consists of a layer of fine material having high conductivity (such as sand) over a layer of coarse material having low conductivity (such as gravel). Unlike a surface barrier (which uses many of the same hydrologic principles), the capillary barrier diverts water away from the object underneath rather than storing the water until evaporation or plant transpiration removes the water. Thus, the capillary barrier is expected to have a significantly longer life and be more effective than a surface barrier for moisture diversion. Although the principles of sand-gravel capillary barriers are well established, such barriers (especially of the size needed for DOE applications) have not been extensively tested. A large-scale sand-gravel capillary barrier needs to be designed, constructed, and operated to obtain performance data to support closure and LLW disposal.

- Getter Materials: To meet the contaminant release specifications for the disposal of Hanford LAW, radiocontaminants are physically trapped in glass. However, only a few of these radionuclides drive the performance assessment. Chemical entrapment of key radionuclides after their release from glass could significantly improve the performance of the waste disposal system. Hydraulic properties of getter materials (original, loaded, and discharged) need to be measured to fully understand waste disposal performance in the presence of getters. The use of getter materials in SRS's disposal of saltstone waste was an important consideration in gaining approval for disposal of that site's tank waste. The use of getter materials is discussed in Problem Element 1.3.1, "Close Tanks."

Workscope to address surface barrier testing includes

- Evaluate natural analogue sites to gain insight regarding long-term stability of capillary and evapotranspiration covers.
- Test barrier performance for postulated failure mechanisms, such as subsidence of a capillary barrier.
- Provide recommendations for surface barrier design and its technical basis.

Data and Tools for Performance Assessment (TFA Technical Response 99058; Work Package WT-12-01, unfunded)
To support tank closure performance assessments for Hanford's ILAW disposal facility, the site needs improved understanding of moisture recharge rates and vadose zone hydrologic properties, because the arid conditions at Hanford are not accurately represented by the existing data.

Specifically with respect to extremely slow recharge rates, Hanford has requested that the range of factors that affect recharge for its ILAW facility be determined. This includes the effect of subsurface disposal facilities on recharge in the vicinity of these facilities and estimation of the spatial and temporal distribution of recharge rates in the vicinity of the disposal facility. Factors to be considered include soil type, vegetation, facility and surface cover design, human activity, climate, and time.

With respect to hydrologic properties, Hanford currently has measurements of the near-surface (first few feet) hydrologic properties, but lacks data at deeper vadose zone depths. Such hydrologic information is desired to support performance assessment calculations on contaminant mobility.

Workscope to address these data needs includes
- Select field monitoring capability for determination of Hanford vadose zone hydrologic properties to depths of 100 feet.
- Perform infiltration field measurements of Hanford vadose-zone hydrologic properties.
- The EM Science Program is funding several projects related to moisture and contaminant transport. The TFA is interested in continuing relevant work through the science program and through applied research funding.
  - Continue development of promising EMSP and related technologies for measurement of moisture content, hydraulic properties, and contaminant concentrations in the vadose zone beneath tank and disposal sites.
  - Continue EMSP and related scientific studies on moisture and contaminant transport properties including recharge rates, hydraulic properties, and contaminant retardation factors.
  - Continue development of EMSP and related computer models for describing moisture and contaminant transport in the vadose zone beneath tank and waste disposal sites.

Problem Element Description and Priority Site Needs

The IHLW from tank waste treatment operations at Hanford, SRS, and INEEL will be stored onsite before being shipped to a federal repository. To ensure the waste form meets disposal requirements, process monitoring, and/or product characterization is required. In addition, HLW canisters may require decontamination before shipment to the repository. This problem element addresses the disposition of the HLW glass canisters and secondary wastes generated during waste processing operations. The following site needs are addressed in this problem element.

Problem Element: 1.3.3 Store and Dispose HLW				
STCG Need Number	**Need Title**	**PBS Number**	**Technical Task**	**OST Number**
SR99-2029	Alternative DWPF Canister Decontamination Technology	SR-HL05	Alternative HLW Canister Decontamination Techniques	N/A
OH-WV-902	Decontamination of High-Level Waste (HLW) Canisters	OH-WV-02	Alternative HLW Canister Decontamination Techniques	2009

Technical Tasks

(TFA Technical Response 99072; Work Package WT-07-01, unfunded)
A new, more effective technology is required to decontaminate the DWPF and WVDP HLW canisters after being filled and welded shut. DWPF canister decontamination includes a water-frit slurry blast technique that removes contamination and oxides from the entire canister exterior surface. The waste from this process comes in two forms. Off-gas is routed to the facility vessel ventilation system and on to facility controlled ventilation exhaust. A water-frit slurry waste stream is pumped into the facility chemical process and is fed into the vitrification process stream, to minimize liquid waste production. This coupling of canister decontamination with chemical processing is less than optimum, could limit production rates in the future, and currently reduces operating flexibility. Ideally, a canister decontamination technique that resulted in only gases that are compatible with the existing ventilation system is preferable. This would minimize or eliminate the dual processing required for canister decontamination and chemical processing. Disposition of oxides and metals removed as part of the process should be specified consistent with the site flow sheets and regulatory requirements. Any constituents added to accomplish canister decontamination should be minimized and should be compatible with the SRS HLW waste management system. The WVDP canisters currently in storage have picked up contamination and must be decontaminated prior to shipment off-site for continued storage. Workscope to address this need includes

- Evaluate enhanced and alternative canister decontamination methods.
- Conduct a pilot-scale and/or full-scale nonradioactive demonstration of recommended enhancements or alternatives for canister decontamination.
- Procure a canister decontamination system.
- Conduct cold testing and qualification testing to demonstrate compliance with WAPS requirements.
- Install/deploy the canister decontamination system.
- Evaluate performance of the canister decontamination system.

Problem Element Description and Priority Site Needs

Tank waste storage, retrieval, treatment, and immobilization activities use equipment that require maintenance to ensure operations, decontamination, and equipment deactivation should failures occur. Radioactive operations frequently require remote operations to protect the health and safety of workers. This problem element provides the tools and processes necessary to ensure continued safe operations of waste storage and treatment facilities. Note: The Deactivation and Decommissioning Focus Area (DDFA) mission is to provide technologies to decontaminate and decommission DOE's surplus facilities. The TFA and DDFA share technical solutions where applicable. The following site needs are addressed in this problem element.

Problem Element: 1.4 Decontamination and Deactivation

STCG Need Number	Need Title	PBS Number	Technical Task	OST Number
OR-TK-02	Tank Solid Waste Retrieval	OR-321, OR-322	Technologies for Pit Operation Enhancement, Remote Operations / Maintenance and Disassembly	2087, 2181, 2195
RL-WT021	Cleaning, Decontaminating and Upgrading Hanford Pits	RL-TW03	Technologies for Pit Operation Enhancement, Remote Operations / Maintenance and Disassembly	2087, 2181, 2195
SR99-2031	Develop Remote Technology to Improve DWPF Operations	SR-HL05	Technologies for Pit Operation Enhancement, Remote Operations / Maintenance and Disassembly	2087, 2181, 2195
SR99-2037	Tank Heel Removal/Closure Technology	SR-HL01, SR-HL02, SR-HL03	Technologies for Pit Operation Enhancement, Remote Operations / Maintenance and Disassembly	2087, 2181, 2195
SR99-2040	Demonstrate Remote Decommissioning and Disassembly of High Level Waste	SR-HL05	Demonstrate Remote Disassembly of HLW Melters and Other Processing Equipment	2383
OH-WV-903	Vitrification Expended Material Processing	OH-WV-01	Demonstrate Remote Disassembly of HLW Melters and Other Processing Equipment	2383
OH-WV-908	Decontamination of High-Level Waste Contaminated Equipment	OH-WV-01	Technologies for Pit Operation Enhancement, Remote Operations / Maintenance and Disassembly	2087, 2181, 2195

Demonstrate Remote Disassembly of HLW Melters and Other Processing Equipment (TFA Technical Response 99077; Work Package WT-06-01)
SRS and WVDP currently do not have the capability to size reduce, decontaminate, classify, and dispose of failed, highly-contaminated processing equipment. This task is divided into two parts: (1) the HLW melter and (2) the rest of the various pieces of equipment, jumpers, etc., that are required to operate and maintain the DWPF. The current approach to dealing with the melter is long-term storage in the canyon facilities on regulated storage pads, or in underground storage vaults. While storage is acceptable for the short term, technology must be developed to properly dispose of this equipment. This should include dismantling and size reduction of the equipment, decontamination and recycling of as much material as possible, disposal of the majority of the material as LLW, and disposal of the remaining HLW materials in a controlled repository or as a recycle stream.

A single failed melter could contain as much HLW glass as five canisters. It could contain additional contamination in the form of unmelted waste solids or as condensed volatile species such as Cs, Ru, and Tc. While failed melters are prime examples to demonstrate this need, it also applies to other equipment such as failed jumpers, off-gas system components, process tanks, equipment, pumps, and others.

This need does not apply just to SRS and WVDP. It spans the entire DOE complex wherever highly contaminated equipment is utilized or generated. Robotic/telerobotic technology currently exists which is capable of disassembly and decontamination of large equipment. The technologies must be adapted for radioactive application. Workscope to address this need includes

- Glass Removal from Failed Melters
  - Identify and evaluate methods for removing glass from failed melters (FY00, TFA, SRS, WVDP, Robotics).
  - Conduct pilot-scale or full-scale non-radioactive demonstration of recommended method for removing glass from failed melter (FY01, FY02, TFA, SRS).
  - Document demonstration of glass removal method (FY02, TFA, SRS, WVDP).
- Failed Equipment D&D, Size Reduction, and Sorting
  - Identify and evaluate methods to D&D, size-reduce, and sort failed melter components and other process equipment (FY00, TFA, SRS, WVDP Valley, Robotics).
  - Issue test plan for demonstration of failed equipment decontamination, size reduction, and sorting (FY00, TFA, SRS, WVDP, Robotics).
  - Complete procurement and deployment of size reduction equipment at WVDP (FY00, ASTD, WVDP).
  - Document deployment of size reduction equipment at WVDP (FY00, ASTD, WVDP).
  - Procure equipment/services to demonstrate D&D, size reduction, and sorting of failed equipment (FY01, FY02, TFA, SRS, WVDP, Robotics).
  - Demonstrate D&D, size reduction, and sorting of failed melter components and other process equipment (FY02, FY03, TFA, SRS, WVDP, Robotics).

Budget Profile: Demonstrate Remote Disassembly of HLW Melters and Other Processing Equipment (TFA Technical Response 99077; Work Package WT-06-01)						
	TTP#	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Hanford						
INEEL						
ORR						
SRS	SR16WT31	150				
WVDP	OH09WT41	185				
TFA Total		335	1540	780	575	TBD
ASTD	OH09WT41	1000				
CMST						
FETC						
ESP						
International						
Robotics	OR17C131	65	210	20	75	
University						
EM-50 Total		1400	1750	800	650	TBD

Technologies for Pit Operation Enhancement, Remote Operations/Maintenance and Disassembly (TFA Technical Response 99052; Work Package WT-04-01)
The DOE waste sites have a number of remote equipment needs for enhancing operations, maintenance, and failed equipment removal/disassembly. Remote technology is needed at Hanford to enhance cleaning, decontamination and reconfiguration operations in radioactive jumper pits for Phase I feed delivery. Remote technologies are needed at SRS to decontaminate and package long-length HLW tank equipment to clear risers for HLW tank retrieval operations, as well as to perform remote operations for maintenance of SRS slurry pumps. Similarly, WVDP needs methods to decontaminate equipment removed from the tanks to Class C radioactivity levels. Remote technology is needed to perform maintenance operations in DWPF process cells where only crane hook mounted impact wrenches are now available.

Remote technology for maintenance of the CPU system at ORNL GAAT will be required such that the GAAT can maintain transfer operations between the gunite tanks and Melton Valley. The CPU and slurry monitoring system will become operational in FY99 at ORR. This will allow the site to begin to monitor the slurries going from W-9 at GAAT to Melton Valley through the cross-site transfer line. Once the system becomes operational, remote systems will be needed to maintain the CPU.

Workscope to address these needs includes

- Hanford Enhanced Pit Operations
  - Provide recommendation regarding proceeding with acquisition and deployment (FY00, Hanford).
  - Procure system for enhanced pit operations (FY00, Robotics, Hanford).
  - Complete cold testing of enhanced pit operations system (FY00, Robotics, Hanford).
  - Conduct hot demonstration of pit operations system (FY01, Hanford).
  - Evaluate the use of a second-generation manipulator to support pit operations (FY01, FY02, Robotics, Hanford).

  - Procure subsystems to enhance pit operations (FY02, Robotics, Hanford).

- SRS Remote Equipment for HLW Tank Component Maintenance and Disposal
  - Identify and evaluate existing technologies for long-length equipment maintenance and disposal, DWPF operations improvements, and DWPF large equipment disposal. Issue recommendations on systems acquistion and deployment (FY00, Robotics, SRS).
  - Conduct feature testing to demonstrate operability of tank component maintenance and disposal systems (FY01, Robotics, SRS).
  - Procure remote equipment of Maintenance and Component Disposal System (FY01, FY02, FETC).
  - Conduct cost testing of Maintenance and Component Disposal System (FY02, Robotics, TFA, SRS).

- SRS Remote Equipment for DWPF Maintenance
  - Prepare specifications for DWPF operational enhancements equipment (FY01, SRS).
  - Procure remote equipment for DWPF operational enhancements (FY02, FETC).

- ORNL Remote Equipment for CPU Maintenance
  - Complete design package for CPU remote maintenance equipment (FY00, Robotics, ORR).
  - Procure CPU remote maintenance equipment (FY00, Robotics).
  - Complete cold testing of CPU maintenance system (FY00, ORR, TFA).
  - Deploy CPU remote maintenance system (FY00, ORR, TFA).
  - Document performance of CPU remote maintenance system (FY01, ORR, TFA).

Budget Profile: Technologies for Pit Operation Enhancement, Remote Operations/Maintenance and Disassembly (TFA Technical Response 99052; Work Package WT-04-01)						
	TTP#	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Hanford	RI09WT22	100				
INEEL						
ORR						
SRS	SR16WT51	100				
WVDP						
TFA Total		200	900	500	TBD	TBD
ASTD						
CMST						
FETC						
ESP						
International						
Robotics	OR17C131 RL00C121 RL37C131 SR10C131	600 600 150 50	900	650		
University						
EM-50 Total		1600	2500	2150	TBD	TBD

Section 7 - References

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Appendix A - Tanks Focus Area Organization

This appendix provides the names of key Tanks Focus Area (TFA) team members. More TFA information may be found on the Internet:

- Office of Science and Technology Tanks Home Page at: http://em-52.em.doe.gov/ifd/tanks/tanks.htm
- TFA Technical Team Home Page at: http://www.pnl.gov/tfa/. This home page also contains an extensive TFA contacts list.

A.1 TFA Organization and Functions

Before FY95, responsibility for remediating the U.S. Department of Energy's (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 high-level waste and transuranic 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 was awarded responsibility for implementing the new approach for tanks. In this effort, Pacific Northwest National Laboratory (PNNL) serves as the lead technical organization. Presently, this team is composed of Idaho National Engineering and Environmental Laboratory (INEEL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), Sandia National Laboratories (SNL), Westinghouse Savannah River Company (WSRC), and Project Hanford Management Contractors (PHMC). The DOE's Richland Operations Office (DOE-RL) serves as the lead operations office and program manager of this team, coordinating the efforts of other site field activities through the TFA Management Team and Site Technology Coordination Groups (STCGs). See Figure A.1, Tanks Focus Area Organization.

The Technical Team is guided by the User Steering Group (USG) composed of senior managers from each of the Technical Team partners, including user members from the five tank sites and three non-user members representing laboratories that participate on the team. The technical program is reviewed by the TFA Technical Advisory Group (TAG), which is composed of technical experts from across the country.

The DOE-RL leads the TFA Management Team, which prioritizes the technical program and ensures TFA technical solutions are integrated into the site plans. The Management Team consists of DOE-Headquarters personnel and Site Representatives from each of the user programs.

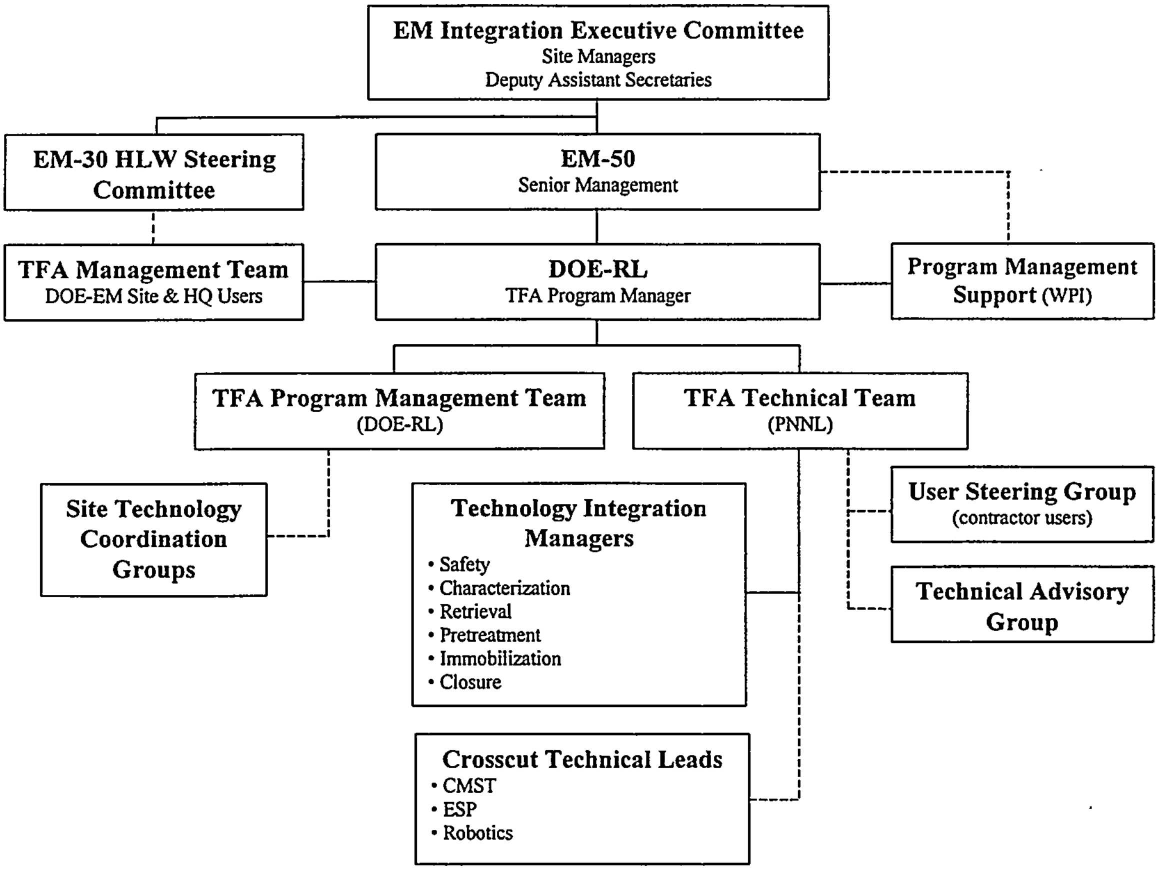

Figure A.1. Tanks Focus Area Organization

These representatives are also responsible for informing their line management, including members of the High-Level Waste Steering Committee, of TFA activities and accomplishments.

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 five major tank sites: Hanford Site, INEEL, Oak Ridge Reservation, Savannah River Site, and West Valley Demonstration Project. Its technical scope covers the major functions that comprise a complete tank remediation system: safety, characterization, retrieval, pretreatment, immobilization, and closure. The TFA integrates tank-related activities across all organizations that fund tank technology development within DOE's Office of Environmental Restoration and Waste Management, comprising the Offices of Waste Management (EM-30), Environmental Restoration (EM-40), and Science and Technology (EM-50). In the future, the TFA will further integrate activities across and beyond the DOE complex as it strives to identify and leverage all available resources to address DOE's tank waste remediation needs.

The following lists provide the names and positions of key TFA personnel.

TFA Management Team

Ted Pietrok, Chair, TFA Program Manager, DOE-RL, Richland, WA
John Drake, Site Representative, West Valley Demonstration Project, West Valley, NY
Kurt Gerdes, TFA DOE-HQ Program Manager, EM-50, DOE-HQ, Germantown, MD
Tom Gutmann, Site Representative, EM-30, DOE-SR, Aiken, SC
Keith Lockie, Site Representative, EM-30, DOE-ID, Idaho Falls, ID
Cavanaugh Mims, EM-40 Representative, DOE-OR, Oak Ridge, TN
Jacquie Noble-Dial, Site Representative, EM-50, DOE-OR, Oak Ridge, TN
Jon Peschong (Joe Cruz, Acting), Site Representative, Office of River Protection, Richland, WA
Ken Picha, EM-30 Representative, DOE-HQ, Germantown, MD
Tom Brouns, (Ex officio member), Technical Team Manager, Pacific Northwest National Laboratory, Richland, WA

TFA Program Management Team

Ted Pietrok, TFA Program Manager, DOE-RL, Richland, WA
Randy Brich, Program Execution Manager, DOE-RL, Richland, WA
Marcus Glasper, Program Integration Manager, DOE-RL, Richland, WA
Lance Mamiya, Program Execution Manager, DOE-RL, Richland, WA
Billie Mauss, Program Development Manager, DOE-RL, Richland, WA

Program Management Support, Waste Policy Institute

Candace Dillman, Manager
Sandy Briggs, Administrative
Eric Dysland, Technical
Jim Hummer, Technical
George Jacobson, Technical
Janna Unterzuber/Rohit Karamchandani, Technical (at DOE-HQ)
Mike Stover, Technical
Brian Walker, Technical
Joan Young, Technical

TFA Technical Team

Tom Brouns, Technical Team Manager, Pacific Northwest National Laboratory, Richland, WA
Bob Allen, Technical Program Integration Manager, Pacific Northwest National Laboratory, Richland, WA
Ronda Biaggi, Administrative Secretary, Pacific Northwest National Laboratory, Richland, WA
Betty Carteret, Technology Delivery Manager, Pacific Northwest National Laboratory, Richland, WA
Kim Collins, Clerk, Pacific Northwest National Laboratory, Richland, WA
Roger Gilchrist, Technical Integration Coordinator, Pacific Northwest National Laboratory, Richland, WA
Lynne Roeder-Smith, Communications, Pacific Northwest National Laboratory, Richland, WA
Steve Schlahta, Technical Operations Coordinator, Pacific Northwest National Laboratory, Richland, WA
Joe Westsik, Deputy Technical Integration Coordinator, Pacific Northwest National Laboratory, Richland, WA
Bonnie Williams, Senior Administrative Secretary, Pacific Northwest National Laboratory, Richland, WA

Technology Integration Managers (TIM)
Larry Bustard, Closure TIM, Sandia National Laboratories, Albuquerque, NM
Pete Gibbons, Retrieval TIM, Numatec Hanford Corporation, Richland, WA
Bill Holtzscheiter, Immobilization TIM, Westinghouse Savannah River Company, Aiken, SC
Phil McGinnis, Pretreatment TIM, Oak Ridge National Laboratory, Oak Ridge, TN
Mike Terry, Safety TIM, Los Alamos National Laboratory, Richland, WA
Tom Thomas, Characterization TIM, Idaho National
Engineering and Environmental Laboratory, Idaho Falls, ID

Crosscut Technical Leads
Glenn Bastiaans, CMST Program, Ames Laboratory, Iowa State University, Ames, IA
Barry Burks, Robotics Program, The Providence Group, Inc., Knoxville, TN
Jack Watson, ESP Program, Oak Ridge National Laboratory, Oak Ridge, TN

TFA User Steering Group

Fred Damerow, West Valley Nuclear Services, West Valley, NY
Tom Hirons, Los Alamos National Laboratory, Los Alamos, NM
Jim Honeyman, Lockheed Martin Hanford Corporation, Richland, WA
Jerry Morin, Westinghouse Savannah River Company, Aiken, SC
Rod Quinn, Pacific Northwest National Laboratory, Richland, WA
Sharon Robinson, Martin Marietta Energy Systems, Inc., Oak Ridge National Laboratory, Oak Ridge, TN
Les Shephard, Sandia National Laboratories, Albuquerque, NM
Jim Valentine, Lockheed Martin Idaho Technologies Company, Idaho National Engineering and Environmental Laboratory, Idaho Falls, ID

TFA Technical Advisory Group

Wally Schulz, Group Chairman, W^{2}S Company, Inc., Albuquerque, NM
Jimmy Bell, Deputy Chairman, Bell Consultants, Inc., Kingston, TN

Pretreatment Subgroup
George Vandegrift, Subgroup Chairman, Argonne National Laboratory, Argonne, IL
John Swanson, Private Consultant, Richland, WA
Major Thompson, Westinghouse Savannah River Company, Aiken, SC

Characterization Subgroup
Gary Eller, Subgroup Chairman, Los Alamos National Laboratory, Los Alamos, NM
Dawn Kaback, Colorado Center for Environmental Management, Denver, CO
Bruce Kowalski, University of Washington, Seattle, WA

Immobilization Subgroup
Tom Weber, Subgroup Chairman, Private Consultant, Kennewick, WA
Joe Gentilucci, JAG Technical Services, Inc., Aiken, SC

Retrieval Subgroup
Paul Scott, Subgroup Chairman, Pacific Northwest National Laboratory, Richland, WA
Brenda Lewis, Westinghouse Savannah River Company, Aiken, SC

Safety Subgroup
Larry Tavlarides, Subgroup Chairman, Syracuse University, Syracuse, NY

Closure Subgroup
Robert Erdmann, Subgroup Chairman, Attorney, Grass Valley, CA
Jimmy Bell, Bell Consultants, Inc., Kingston, TN

At-Large Members
John Carberry, DuPont, Wilmington, DE
Greg Choppin, Florida State University, Tallahassee, FL
Larry Tavlarides, Syracuse University, Syracuse, NY

Appendix B – Paths to Closure Data

Table B.1 presents the primary data used by the TFA to

- develop technical responses to needs submitted by the sites in FY99
- issue Program Execution Guidance for FY00, and
- form the FY01 Corporate Review Budget submission.

Each site need submitted by the sites is listed, along with the Path to Closure priority of the need, the related Program Baseline Summaries, associated waste streams, and the technical risk assigned to each waste stream.

Table B.1. Tanks Focus Area Path to Closure Data

Site	Site Need ID	Need Title	PTC Priority	PBS#	Waste Stream (WS) Name	WS Technical Risk	
						Inventory	Generation
Hanford	RL-WT01	Technetium-99 Analysis in Hanford Tank Waste and Contaminated Tank Farm Areas	2	RL-TW01	Sludge, Salt, Liquid	1	1
	RL-WT04	DST Corrosion Monitoring	2	RL-TW03	Sludge, Salt, Liquid	1	1
	RL-WT05	Remote Inspection of High-Level Waste Single-Shell Tanks	3	RL-TW03	Sludge, Salt, Liquid	1	1
	RL-WT06	Identification and Management of Problem Constituents for HLW Vitrification	1	RL-TW05	Sludge, Salt, Liquid	1	1
	RL-WT09	Representative Sampling and Associated Analysis to Support Operations and Disposal	1	RL-TW01	Sludge, Salt, Liquid	1	1
				RL-TW05	Sludge, Salt, Liquid	1	1
	RL-WT013	Establish Retrieval Performance Evaluation Criteria	1	RL-TW04	Sludge, Salt, Liquid	1	1
	RL-WT015	Standard Method for Determining Waste Form Release Rate	2	RL-TW09	LAW Glass	1	0
	RL-WT016	Glass Monolith Surface Area	2	RL-TW09	LAW Glass	1	0
	RL-WT017	Long-Term Testing of Surface Barrier	3	RL-TW09	LAW Glass	1	0
					Tanks	1	1
	RL-WT018	Testing of Sand-Gravel Capillary Barrier	3	RL-TW09	LAW Glass	1	0
					Tanks	1	1
	RL-WT021	Cleaning, Decontaminating and Upgrading Hanford Pits	2	RL-TW03	Sludge, Salt, Liquid	1	1
	RL-WT022	Tank Knuckle NDE	3	RL-TW03	Sludge, Salt, Liquid	1	1
	RL-WT023	Prediction of Solid Phase Formation in Static and Dynamic Hanford Tank Waste Solutions	2	RL-TW04	Sludge, Salt, Liquid	1	1
	RL-WT024	Enhanced Sludge Washing Process Data	3	RL-TW05	Sludge, Salt, Liquid	1	1
	RL-WT026	Tank Leak Detection Systems for Underground Single-Shell Waste Storage Tanks (SSTs)	1	RL-TW03	Sludge, Salt, Liquid	1	1
	RL-WT027	Tank Leak Mitigation Systems	1	RL-TW04	Sludge, Salt, Liquid	1	1
	RL-WT029	Data and Tools for Performance Assessments	2	RL-TW09	LAW Glass	1	0
					Tanks	1	1
	RL-WT060	PHMC Retrieval and Closure - Hanford/SRS Waste Mixing Mobilization	2	RL-TW04	Sludge, Salt, Liquid	1	1
	RL-WT061	Reactive Barriers to Contaminant Migration	3	RL-TW04	LAW Glass	1	0
					Tanks	1	1

Table B.1. (contd)

Site	Site Need ID	Need Title	PTC Priority	PBS#	Waste Stream (WS) Name	WS Technical Risk	
						Inventory	Generation
Hanford	RL-WT062	PHMC DST Retrieval - Hanford DST Transfer Pump Improvements	2	RL-TW04	Sludge, Salt, Liquid	1	1
	RL-WT063	PHMC Retrieval and Closure - Hanford SST Saltcake Dissolution Retrieval	2	RL-TW04	Sludge, Salt, Liquid	1	1
	RL-WT064	PHMC Retrieval and Closure - Hanford Past Practice Sluicing Improvements	2	RL-TW04	Sludge, Salt, Liquid	1	1
	RL-WT065	Direct Inorganic and Organic Analyses of High-Level Waste	3	RL-TW05	Sludge, Salt, Liquid	1	1
	RL-WT066	Compositional Dependence of the Long Term Performance of Glass as a Low-Activity Waste Form	2	RL-TW09	LAW Glass	1	0
INEEL	ID-2.1.06	TRU, Cs and Sr Removal from High Activity Wastes	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.15	Neutralization of Newly Generated Liquid Wastes	1	ID-HLW-103	Liquids	1	1
	ID-2.1.16	Decon Facility/Analytical Facility Waste Reduction	1	ID-HLW-101	Liquids	1	1
	ID-2.1.17	Develop New Filter Leach Process	1	ID-HLW-101	Liquids	1	1
	ID-2.1.18	Continuous Emissions Monitor for Offgas Analysis	1	ID-HLW-101	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.19	EPA Methods Sample Collection and Analysis Verification/Development	1	ID-HLW-101	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.20	Tank Annulus/Vault Inspection	1	ID-HLW-103	Tanks	1	1
	ID-2.1.23	Low-Activity Wasteform Qualification	1	ID-HLW-103	Liquids	1	1
	ID-2.1.24	Integration/Optimization of High Activity Waste/Low Activity Waste Process Flowsheet	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1
					Tanks	1	1
	ID-2.1.25	Ion-Exchange System for Water Runoff	1	ID-HLW-101	Liquids	1	1
	ID-2.1.26	Nested Array Fluidic Sampler for Tank Solution Characterization	1	ID-HLW-101	Liquids	1	1
	ID-2.1.27	Blowback Metal Filters for Solids (Calcine) Retrieval	1	ID-HLW-103	Calcine Solids	1	0
	ID-2.1.28	Cs Removal from Newly Generated Liquid Waste	1	ID-HLW-103	Liquids	1	1
	ID-2.1.29	Evaluate Chloride Corrosion Potential (LET&D/PEWE/Future Processes)	1	ID-HLW-101	Liquids	1	1
	ID-2.1.30	Remove/Treat Chlorides (LET&D/PEWE/Future Processes)	1	ID-HLW-101	Liquids	1	1
	ID-2.1.31	Characterization of Entrainable Solids in Tank Waste	1	ID-HLW-103	Liquids	1	1

Table B.1. (contd)

Site	Site Need ID	Need Title	PTC Priority	PBS#	Waste Stream (WS) Name	WS Technical Risk	
						Inventory	Generation
INEEL	ID-2.1.35	Direct Immobilization of INTEC Sodium-Bearing Waste	1	ID-HLW-103	Liquids	1	1
	ID-2.1.36	Mercury Removal from Liquid Wastes	1	ID-HLW-101	Liquids	1	1
	ID-2.1.38	Conditioning of Low Activity Waste for Treatment	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.39	Acceptance Criteria for LAW Disposal in Underground Storage Tanks	1	ID-HLW-103	Liquids	1	1
					Tanks	1	1
	ID-2.1.40	Low Activity Waste Grout Sorbent Addition to Reduce Leachability	1	ID-HLW-103	Liquids	1	1
	ID-2.1.41	HLW Process Offgas Treatment	1	ID-HLW-101	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.42	Acceptance Criteria for Tank Closure	1	ID-HLW-105	MLLW from HLW to WERF Incin	1	0
					Tanks	1	1
	ID-2.1.43	Certify LDUA Sampler as EPA-Approved Method of Sampling Tank Heel Liquids	1	ID-HLW-103	Liquids	1	1
					Tanks	1	1
	ID-2.1.44	Certify LDUA Sampler as EPA-Approved Method of Sampling Tank Heel Solids	1	ID-HLW-103	Liquids	1	1
					Tanks	1	1
	ID-2.1.45	Acceptance Criteria for Grouting Tank Heels	1	ID-HLW-103	Tanks	1	1
	ID-2.1.46	Management of Tank Heel Liquids	1	ID-HLW-105	Tanks	1	1
	ID-2.1.47	Management of Tank Heel Solids	1	ID-HLW-105	Tanks	1	1
	ID-2.1.48	Wasteform Qualification for Low-Activity Waste in Underground Storage Tanks	1	ID-HLW-103	Liquids	1	1
					Tanks	1	1
	ID-2.1.49	Acceptance Criteria for High Activity Waste/Low Activity Waste	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.50	Solids Waste (Calcine) Retrieval	1	ID-HLW-103	Calcine Solids	1	0
	ID-2.1.51	Develop Calcine Dissolution Kinetics for Solid/Liquid Equilibria	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.52	Characterization of Solids from Calcine Dissolution	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.53	Cs Removal from High Activity Wastes	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.54	TRU Removal from High Activity Wastes	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1

Table B.1. (contd)

Site	Site Need ID	Need Title	PTC Priority	PBS#	Waste Stream (WS) Name	WS Technical Risk	
						Inventory	Generation
INEEL	ID-2.1.55	Sr Removal from High Activity Wastes	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.56	Mercury Treatment for Aluminum Calcine	1	ID-HLW-103	Calcine Solids	1	0
	ID-2.1.57	Conditioning of HAW for Treatment	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.58	HAW Immobilization	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1
	ID-2.1.62	Acceptance Criteria for Bin Set Closure	1	ID-HLW-103	Calcine Solids	1	0
	ID-2.1.63	Universal Solvent Process for TRU, Cs and Sr Removal	1	ID-HLW-103	Calcine Solids	1	0
					Liquids	1	1
ORR	OR-TK-01	Tank Waste Characterization	3	OR-311	Remote-Handled TRU Sludges	1	1
	OR-TK-02	Tank Solid Waste Retrieval	1	OR-321	Remote-Handled TRU Sludges	1	1
				OR-322	Remote-Handled TRU Sludges	1	1
	OR-TK-04	Sludge Mixing and Slurry Transport	1	OR-321	Remote-Handled TRU Sludges	1	1
				OR-322	Remote-Handled TRU Sludges	1	1
	OR-TK-05	Tank Sludge and Supernatant Separations	1	OR-311	Liquid LLW	1	1
					Remote-Handled TRU Sludges	1	1
	OR-TK-09	Tank Closure	3	OR-321	Remote-Handled TRU Sludges	1	1
				OR-322	Remote-Handled TRU Sludges	1	1
	OR-TK-11	Tank Supernatant Pretreatment	1	OR-311	Liquid LLW	1	1
					Remote-Handled TRU Sludges	1	1
SRS	SR99-1011	Demonstrate Evaporation Technologies to Reduce Generation of Secondary Waste Volume from Consolidated Incineration Facility	2	SR-SW01	Char. Incinerable Debris	1	3
					Char. Organic Liquid	1	1
					CIF Ash	1	0
					Incinerable Low Activity Job Control Waste	1	1
					Listed Aqueous Liquid	1	1
					Listed Incinerable Debris	1	3
					Listed Organic Liquid	1	1
					WSF Sort/Seg for CIF	1	0

Table B.1. (contd)

Site	Site Need ID	Need Title	PTC Priority	PBS#	Waste Stream (WS) Name	WS Technical Risk	
						Inventory	Generation
SRS	SR99-2027	Demonstrate Alternative Filtration Technologies to Replace HEPA Filters	3	SR-HL01	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
				SR-HL02	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
	SR99-2028	Alternative Waste Removal Technology	1	SR-HL01	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
				SR-HL02	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
				SR-HL03	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
	SR99-2029	Alternative DWPF Canister Decon Technology	3	SR-HL05	Vitrified HLW	5	0
	SR99-2031	Develop Remote Technology to Improve DWPF Operations	3	SR-HL05	Vitrified HLW	5	0
	SR99-2032	Optimize Melter Glass Chemistry	2	SR-HL05	Vitrified HLW	5	0
	SR99-2033	Provide Alternative Processing and/or Concentration Methods for DWPF Recycle Aqueous Streams	2	SR-HL01	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
				SR-HL02	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
				SR-HL05	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
	SR99-2034	Second Generation Salt Feed Preparation	1	SR-HL07	ITP Filtrate to Saltstone	1	0
					ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1

Table B.1. (contd)

Site	Site Need ID	Need Title	PTC Priority	PBS#	Waste Stream (WS) Name	WS Technical Risk	
						Inventory	Generation
SRS	SR99-2035	Develop Advanced Techniques for Life Extension of High Level Waste Tanks and Piping	3	SR-HL01	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
				SR-HL02	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
				SR-HL03	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
	SR99-2036	Develop Second Generation DWPF Melter	3	SR-HL05	Vitrified HLW	5	0
	SR99-2037	Tank Heel Removal/Closure Technology	1	SR-HL01	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
				SR-HL02	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
				SR-HL03	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1

Table B.1. (contd)

Site	Site Need ID	Need Title	PTC Priority	PBS#	Waste Stream (WS) Name	WS Technical Risk	
						Inventory	Generation
SRS	SR99-2039	Methods to Unplug Waste Transfer Lines	2	SR-HL01	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Salt/Sup. Feed to ITP - NMS	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
				SR-HL02	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Salt/Sup. Feed to ITP - NMS	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
				SR-HL03	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Salt/Sup. Feed to ITP - NMS	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
	SR99-2040	Demonstrate Remote Decommissioning and Disassembly of High Level Waste Processing Equipment	3	SR-HL05	Failed Glass Melters	5	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Tanks Stabilized	1	0

Table B.1. (contd)

Site	Site Need ID	Need Title	PTC Priority	PBS#	Waste Stream (WS) Name	WS Technical Risk	
						Inventory	Generation
SRS	SR99-2041	Demonstration of Alternative Mixer Technology for HLW Pump Tanks	3	SR-HL01	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
				SR-HL02	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
				SR-HL03	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
	SR99-2044	Demonstrate In-Situ Characterization Weight Percent Probe	2	SR-HL01	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
				SR-HL02	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0
				SR-HL03	ITP Precipitate to DWPF	1	0
					Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Washed Sludge to DWPF	1	0

Table B.1. (contd)

Site	Site Need ID	Need Title	PTC Priority	PBS#	Waste Stream (WS) Name	WS Technical Risk	
						Inventory	Generation
SRS	SR99-2045	In-Situ Waste Tank Corrosion Probe	2	SR-ER02	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Tanks Stabilized	1	0
				SR-HL01	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Tanks Stabilized	1	0
				SR-HL03	Salt/Sup. Feed to ITP - Legacy	1	1
					Sludge Feed to ESP - Legacy	1	1
					Sludge Feed to ESP - NMS	1	1
					Tanks Stabilized	1	0
	SR99-2051	Technology to Mitigate Effects of Technetium Under Tank Closure Conditions	1	SR-HL03	Tank Stabilization Initiated	1	0
					Tank Washing Initiated	1	0
	SR99-3022	In-situ Grouting and/or Retrieval of Waste from Underground Tanks	2	SR-ER02	MLLW Solvents	1	1
WVDP	OH-WV-902	Decontamination of High-Level Waste (HLW) Canisters	1	OH-WV-02	Tanks	1	1
	OH-WV-903	Vitrification Expended Material Processing	1	OH-WV-01	Tank Cleanout Residues	1	1
	OH-WV-904	High-Level Waste Tank Closure	1	OH-WV-02	Cleaned HLW Tanks	1	1
	OH-WV-905	Retrieval of Tank Heels	1	OH-WV-01	Tank Cleanout Residues	1	1
	OH-WV-906	Radioactivity Measurement of High-Level Waste Tank Residuals	1	OH-WV-01	Tank Cleanout Residues	1	1
	OH-WV-908	Decontamination of High-Level Waste Contaminated Equipment	1	OH-WV-01	Unknown	0	0

Appendix C - Prioritization Process

Each fiscal year, the Tanks Focus Area (TFA) reviews its prioritization process and amends it according to any changes in programmatic requirements, such as changes in strategic and tactical approaches. Amendments to the prioritization process must be approved by the TFA's user community. Therefore, this appendix describes the process used in FY99. Modifications to this process may occur as the TFA works with its users to execute the program development activities scheduled in FY00.

C.1 Program Development Process

The TFA's prioritization process is but one component of the overall program development process. The entire program development process will be summarized here to provide a more comprehensive understanding of the prioritization process in a user-driven technology development program. The program development steps include (see Figure C.1)

(1) Site Technology Coordinating Group (STCG) needs submission and TFA screen
(2) Needs analysis
(3) Strategic task identification
(4) Technical response development
(5) Response rating
(6) TFA Management Team prioritization.

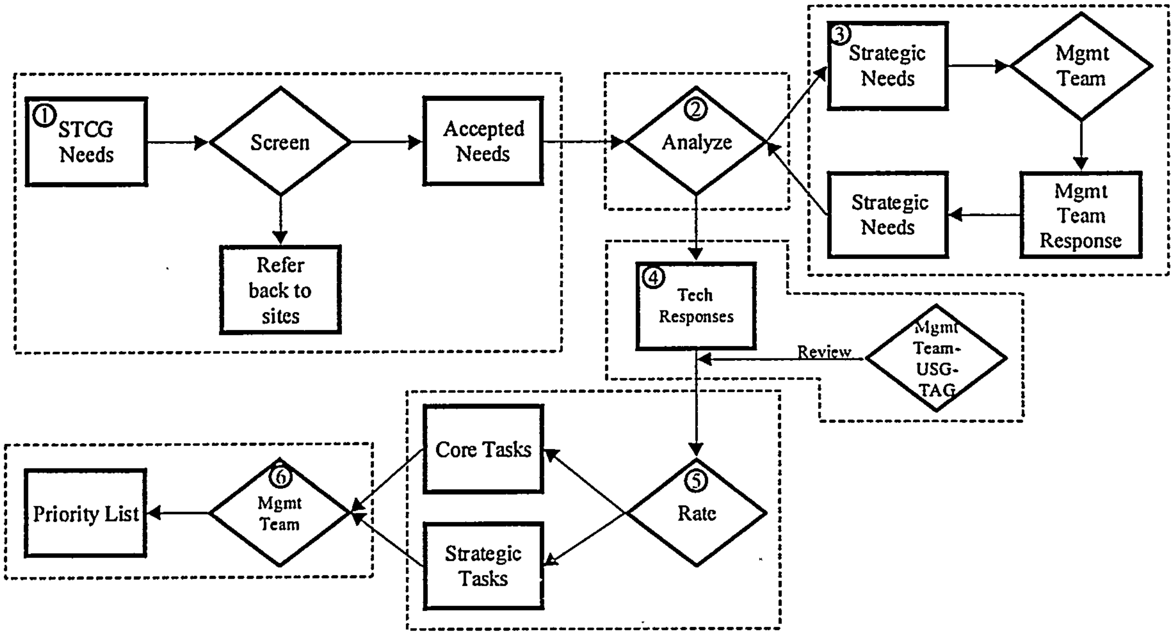

Figure C.1. Tanks Focus Area Technical Response Development Process

C.1.1 STCG Needs Submission and TFA Screen

Typically, the TFA received its annual update of site needs anywhere from November through January. For FY99, the TFA requested the sites submit their needs as early as possible in the first quarter of the fiscal year. The TFA believed earlier needs submissions would allow the TFA to construct and prioritize a comprehensive program more tightly bound to other U.S. Department of Energy (DOE) Office of Science and Technology (EM-50) resources. In response to the TFA's request, the sites, in general, communicated their science and technology needs statements earlier than in any previous year. However, as the TFA experienced the full impact of operating under the "Focus Area-centered" approach, it became apparent that in the future site needs must be received even earlier during the month of October, to support technical response and budget development requirements.

After needs submittal, the TFA screened the needs for relevance to the TFA program. The screening criteria identify site needs that fall outside of the TFA mission area, needs without a technology development component, or the unfeasibility of developing technical solutions within the time frame needed. The screening criteria are

a) **Within the TFA mission area** - The TFA coordinates with the sites and other potential Focus Areas the disposition of needs not believed to be within its mission area.

b) **Technology development component** - The need must require technology development, first-time hot demonstration or deployment, or reengineering. The TFA recognizes that some needs may be satisfied through the use of technology already developed or may be candidates for resolution through the Accelerated Site Technology Deployment (ASTD) program. The TFA does not respond to needs that do not have a technology development requirement.

c) **Technical feasibility** - Some needs may require a technical solution sooner than one can be developed by the TFA or may be not feasible due to cost.

C.1.2 Needs Analysis

The TFA analyzed each site need that passed through the screening criteria. This analysis served to familiarize the TFA with the general scope of site needs. The TFA worked interactively with the sites to better understand the problem to be solved, required performance specifications, timing of the technical solution, integration of functional interfaces (e.g., between pretreatment and immobilization), and interfaces with other OST programs.

C.1.3 Strategic Task Identification

Focusing predominately on the analysis of site-submitted needs, the TFA identified needs whose solutions were considered strategic in nature to the TFA or the sites. Additionally, the

TFA identified technology "gaps" that became apparent in the needs analysis, or that were identified through other TFA processes, such as technology interface workshops. The TFA Technical Advisory Group (TAG) provided advice and guidance on the identification and scope of proposed strategic tasks. The TFA submitted strategic tasks for review by its TFA Management Team, and eventually to the High-Level Waste Steering Committee (HLWSC). The TFA Management Team either voiced no objection to the development of a technical response to these strategic issues for inclusion within the TFA list of needs, or determined that the issue merited no further TFA consideration. Unfortunately, the TFA did not have sufficient time to fully coordinate potential input from the HLWSC.

The TFA developed and refined its own definition of a strategic task. The following points define a TFA strategic task

- Pursues a problem identified within a site baseline, but not currently being addressed. This problem is longer-term and may otherwise go unsatisfied due to budget limitations and priority. An official need may or may not have been submitted by the STCG of a specific site. (A previous example may be the Hanford Tanks Initiative's work on the performance objectives and decision process for tank closure. HTI was initiated as a strategic investment.) Successful TFA response to the need may result in

    - Accelerated schedule
    - Risk reduction (programmatic or technical)
    - Establishment of a technical or programmatic basis that drives near-term related baseline efforts.

- Resolves a technical roadblock or problem that has recently been identified. This problem may be near- or long-term in nature, and may or may not be associated with baseline technologies or flowsheets. This problem may be identified by the TFA or external reviewers, rather than officially submitted as a need by a specific site. (Example: TFA's work in the prevention of solids formation for Hanford waste retrieval and transfer. especially with respect to feed delivery to support treatment and immobilization activities. This was not originally submitted as a site need until identified as a potential roadblock or technical risk based on test results from other EM-30 and -50 work.) Satisfaction of this need may result in

    - Prevention of recently identified problems
    - Technical contingency through identification of another viable technical approach
    - Risk reduction (programmatic or technical).

- Effects a change to a baseline (alternative). The problem could be near-term and may require that the TFA leverage other programs. An official need may or may not have been submitted by a site. (Example: TFA's early work in cesium alternatives for SRS via the Efficient Separations Program [ESP]. This work provided alternatives for consideration in the salt disposition project). Successful response to the need may result in

- Mortgage reduction
- Risk reduction (programmatic or technical).

The TFA still seeks wide support for the concept of selective identification and funding of strategic tasks. While extremely limited funding may inhibit the TFA's ability to initiate new start strategic activities in the immediate future, discussion of the strategic task concept still proves very useful, philosophically, for the TFA. The TFA intends to continue the pursuit of this concept.

C.1.4 Technical Response Development

The TFA developed technical responses to all needs passing through the screening criteria. Those needs screened out were coordinated with the submitting site for further disposition. Some needs were screened out as potentially outside of the TFA mission area, being best addressed within a different OST program, such as another Focus Area. In such cases, the TFA interacted with the other programs and coordinated with the submitting site of any need identified in this process.

Responses were prepared by the Technical Team and submitted to the Technical Advisory Group (TAG), USG, and TFA Management Team for review and comment. To the maximum extent possible, the TFA integrated responses to similar needs. Also, the TFA was careful to take advantage of other OST funding sources to maximize leveraging opportunities.

C.1.5 Response Rating

The TFA rated each technical response for use in funding decisions based on approved task selection criteria. Technical responses rated above the anticipated funding line are known as "core" tasks and generally form the basis for "target" budget funding levels. Selected technical responses below the funding line were considered for TFA funding if they were previously identified as a strategic task. These strategic tasks were highlighted for Management Team review and prioritization with rationale describing the benefits of investments relative to the TFA's strategic intent.

The TFA studied each need and developed draft integrated technical responses. As necessary, the TFA contacted the specific technical point of contact for further need clarification. From mid-January through early-March 1999, the TFA prepared an initial draft response for each need. The composite set of technical responses was rated against criteria intended to rank them for further program development activities. The criteria included the following (see Section C.2 for a full definition of the criteria):

- Broad-based benefit
- User commitment to deploy
- Relationship to Paths to Closure
- Other technical impact
- Implementation potential.

C.1.6 TFA Management Team Prioritization

The TFA technical response prioritization took place on March 25, 1999, in conjunction with TFA Midyear activities. During prioritization, the TFA Technical Team introduced each technical response to the TFA Management Team. The Management Team discussed the merits of each response, focusing closely on aspects of site benefits and user commitment, and assigned scores to each technical response according to the approved prioritization criteria. At the conclusion of the prioritization session, the Management Team affirmed the results, thereby creating the official TFA FY 2000-2001 Integrated Priority Listing (IPL).

The TFA finalized the technical responses, incorporating actions directed by the Management Team during prioritization. The final version of the technical responses formed the basis for issuance of Program Execution Guidance (PEG), and the responses are posted on the Technical Team home page (http://www.pnl.gov/tfa).

C.2 Prioritization Criteria

The TFA uses five prioritization criteria. They are defined below.

1) Broad-Based Benefit - This criterion addressed the potential complex-wide benefit of a technical response.

High: *Two* or more different site STCG-submitted needs with strong interest in a single, integrated response. Note: "strong interest" means site interest is confirmed with the TFA Site Representative and USG member.

High to Medium:

- High/Medium: One STCG-submitted need; two or more sites with strong interest where resulting hardware or data would *directly* benefit.

- Medium/High: One STCG-submitted need; one site with strong interest where resulting hardware or data would *directly* benefit.

- Medium: One STCG-submitted need; one site with strong interest where resulting hardware or data would *indirectly* benefit.

Medium Low: One STCG-submitted need that may be satisfied through deployment of a technology already deployed elsewhere, but still requiring technology development work.

Low/Medium: One STCG-submitted need and one other potential benefiting site based on Technology Integration Manager (TIM) judgment.

Low: One STCG-submitted need; site specific.

2) User Commitment - The TFA values user commitment to the development and deployment of technical solutions. This criterion assesses the strength of user commitment to share the burden of a technology's development and deployment.

High:

- Site co-funds development and demonstration (or deployment)
- High commitment to deploy through out-year baseline, PBS, and budget request; memorandum of understanding (MOU) or other signed document for TFA next year expenditures over $1M
- Is in site baseline operational plan with MOU or other signed document committing to funding and plan for deployment in subject FY
- Deployment within 1 - 2 years
- Greater than or equal to co-funding of development and demonstration for the year of prioritization and duration of the technical response.

High/Medium: Response results in data delivery for key DOE decisions, e.g., Environmental Impact Statement (EIS) or privatization decisions.

- Site co-funds data development and delivery
- Data will be used within 1 - 2 years
- High commitment to deploy through out-year baseline, PBS, and budget request; MOU or other signed document for TFA expenditures over $1M
- Greater than or equal to co-funding of development and delivery for the year of prioritization and duration of the technical response.

Medium/High: Approximately equal co-funding to develop and demonstrate during time of the technical response. High commitment to deploy through out-year baseline, PBS, and budget request; TFA Site Representative commitment to obtain MOU or other signed document for TFA next FY expenditures over $1M.

Medium: Approximately one-quarter co-funding; high commitment to deploy through out-year baseline, PBS, and budget request; TFA Site Representative commitment to obtain MOU or other signed document for TFA next FY expenditures over $1M.

Low/Medium: Some co-funding (large percentage or small), but with no commitment to deploy or use data (not in out-year plan).

Low: Little or no indication of site co-funding or commitment to deploy.

Note on co-funding: Co-funding must focus on support to the overall project TFA is funding. Co-funding may include direct support to the principal investigator, support to on-site operations staff to facilitate testing, sample collection/analysis/shipping, design and review. Examples of co-funding include ORR Gunite and Associated Tanks cold testing support, and SRS Tank 20 closure (application of TFA-funded grout test work).

3) Relationship to Paths to Closure - This criterion considers the Paths to Closure (PTC) priority, critical path milestone risks, and waste stream risks related to a technical response.

Paths to Closure Priority

- High: Technical response addresses at least two needs with a PTC priority of 1, or three needs with a PTC priority of 2.
- Medium: Technical response addresses at least one need with a PTC priority of 1, or two needs with a PTC priority of 2.
- Low: Technical response addresses at least one need with a PTC priority of 2. (Note: no value is assigned to a technical response addressing needs with a PTC priority of 3.

Paths to Closure Risk

- High: Must meet one of two conditions: 1) related critical path milestone technology risk or critical path milestone work scope definition risk is high (risk rating of 4 or 5), or 2) related waste stream technology risk or waste stream work scope definition risk is high (risk rating of 4 or 5).
- Medium: Must meet one of two conditions: 1) related critical path milestone technology risk or critical path milestone work scope definition risk is medium with a risk rating of 3, or 2) related waste stream technology risk or waste stream work scope definition risk is medium with a risk rating of 3.

- Low: Must meet one of two conditions: 1) related critical path milestone technology risk or critical path milestone work scope definition risk is medium or low with a risk rating of 2 or 1, or 2) related waste stream technology risk or waste stream work scope definition risk is medium or low with a risk rating of 2 or 1.

4) Other Technology Impact - The objective of this criterion is to broadly assess the overall potential technology impact of a technical response. The TFA considers a response's impact on schedule, cost avoidance, and link to regulatory requirements to determine impact. The ratings include:

High: (one or more of the following apply)

- Technology required to meet baseline assumptions in the Paths to Closure
- Documented high cost avoidance (over $250M) to EM (information, including uncertainty analysis, must be provided to TFA by site)
- Possesses high cost reduction potential (over $250M)
- Technical response is required to meet firm regulatory requirements that could delay tank waste remediation schedules.

Medium: (one or more of the following apply)

- Technology required to meet enhancements or alternatives to baseline in Paths to Closure
- Documented moderate cost avoidance (between $250M and $50M) to EM or general consensus on high cost avoidance (over $250M) that cannot be documented due to lack of data that will be developed if the task goes forward
- Possesses moderate cost reduction potential
- Technical response adds assurance that regulatory requirements are met, or supports a regulatory requirement that the site may renegotiate.

Low: (one or more of the following)

- Appears that technology could meet baseline or enhancement assumptions, but more data is needed and will be provided explicitly if the task proceeds
- General consensus that moderate cost avoidance (between $250M and $50M) could be achieved but cannot yet be documented
- Technical response's link to regulatory requirements is not fully determined.

5) Implementation Potential - This criterion values a strategic task that has the potential to result in an implementation.

High: No barriers, technical or otherwise, are believed to exist that would prohibit development and implementation of a solution to the problem prior to the required date.

Medium: No technical barriers are believed to exist that would prohibit development and implementation of a solution to the problem prior to the required date. Other barriers may exist, such as political, stakeholder, regulatory or programmatic.

Low: No barriers are believed to exist that would prohibit development and implementation of a solution to the problem, however the required date cannot be met.

C.3 Present Program Prioritization

The prioritization process serves at least three purposes for the TFA. First, it fine-tunes the program scheduled for execution in the upcoming fiscal year. Second, it forms the basis for development of the Corporate Review Budget (CRB) supporting the following year. Third, it adds shape to the program in the 3 years following the CRB year. The TFA's Prioritized Project Listing for FY00-FY01 appears in Table C.1, including the TFA's funding priority, the needs submitted by the sites, potential DOE/EM-50 technologies to be applied to the needs, and a funding profile of potential EM-50 funding.

Table C.1. Tanks Focus Area FY00 - FY01 Prioritized Project List

TFA Priority	TFA Response ID	Site	Site Need ID	OST Tech ID	TFA Technical Response Title	FY00 $K	FY01 $K	FY02 $K	FY03 $K	FY04 $K
1	99068	INEEL	ID-2.1.57	2009, 2092	Improve Performance and Design of HLW Melters	1475	1525	1300	TBD	TBD
			ID-2.1.57							
			ID-2.1.58							
			ID-2.1.58							
		SRS	SR99-2036							
2	99054A	Hanford	RL-WT023	233, 2096, 2367	Prevention of Solids Formation	1875	2450	1475	0	0
			RL-WT037-S							
			RL-WT038-S							
			RL-WT040-S							
			RL-WT049-S							
			RL-WT050-S							
		ORR	OR-TK-02							
		SRS	SR99-2039							
3	99043	Hanford	RL-WT04	1985, 2015	High-Level Waste Tank Corrosion Control and Monitoring	655	535	0	TBD	TBD
		ORR	OR-TK-01							
		SRS	SR99-2045							
4	99067	Hanford	RL-WT013	812, 1510, 1511, 1989, 2011, 2012, 2097, 2117, 2232, 2366, 2370	Tank Heel Retrieval Technology	3850	4225	5200	TBD	TBD
			RL-WT027							
			RL-WT064							
		INEEL	ID-2.1.47							
		ORR	OR-TK-02							
		SRS	SR99-2037							
		WVDP	OH-WV-905							
5	99073	Hanford	RL-WT064	2009	Improve Waste Loading and HLW Glass	1600	1900	1400	TBD	TBD
			RL-WT033-S							
		INEEL	ID-2.1.58							
		SRS	SR99-2032							
6	99077	SRS	SR99-2040	2383	Demonstrate Remote Disassembly of HLW Melters and Other Processing Equipment	1400	1750	800	TBD	TBD
		WVDP	OH-WV-903							
7	99086	ORR	OR-TK-11	20, 21, 2096	ASTD Evaporation and Treatment Processing	1795	820	0	0	0
		SRS	SR99-1011							
8	99019	INEEL	ID-2.1.23	21, 82, 2094, 2371	Conditioning and Immobilization of Low-Activity Waste to Meet Waste Acceptance Criteria	1625	1530	400	TBD	TBD
			ID-2.1.28							
			ID-2.1.35							
			ID-2.1.38							
			ID-2.1.40							
		ORR	OR-TK-06							

Table C.1. (contd)

TFA Priority	TFA Response ID	Site	Site Need ID	OST Tech ID	TFA Technical Response Title	FY00 $K	FY01 $K	FY02 $K	FY03 $K	FY04 $K
9	99023	INEEL	ID-2.1.39 ID-2.1.42 ID-2.1.45 ID-2.1.46 ID-2.1.47 ID-2.1.48 ID-2.1.62	22, 82, 2094, 2368	Idaho Tank WM-182 Closure Demonstration	600	800	800	TBD	TBD
10	99085	ORR SRS WVDP	OR-TK-09 SR99-3022 OH-WV-904	22, 2368	Demonstration of Grout Injection Technology for Tank Closure	1350	500	0	0	0
11	99003	INEEL	ID-2.1.16 ID-2.1.17	0	Decontamination Methods Development	485	685	60	0	0
12	99070	Hanford INEEL SRS	RL-WT048-S ID-2.1.38 SR99-2034	21, 2009	Salt Cesium Separation Processes	7750	6600	5600	TBD	TBD
13	99082	ORR SRS	OR-TK-02 OR-TK-03 SR99-3022	82, 1511, 2232, 2370	Horizontal and Small Tank Sludge Mixing and Mobilization	1001	1250	0	0	0
14	99057	Hanford WVDP	RL-WT026 RL-WT027 OH-WV-907	0	Tank Leak Detection, Monitoring, and Mitigation	300	300	0	0	0
15	99054B	Hanford	RL-WT023 RL-WT063	1989, 2096	Saltcake Dissolution	475	445	0	0	0
16	99075	Hanford INEEL ORR SRS	RL-WT022 RL-WT05 RL-WT055-S ID-2.1.20 OR-TK-01 SR99-2035 SR99-2050-S	85, 130, 860, 890, 1996	Tank Inspection and Integrity Techniques for Hanford, SRS, ORR, and INEEL	1395	1750	1850	TBD	TBD
17	99076	Hanford ORR SRS	RL-WT023 RL-WT040-S OR-TK-02 SR99-2035 SR99-2039	233, 350, 1510, 2367	Waste Transfer Line Plugging Prevention and Unplugging Methods	1125	1850	2175	TBD	TBD

Table C.1. (contd)

TFA Priority	TFA Response ID	Site	Site Need ID	OST Tech ID	TFA Technical Response Title	FY00 $K	FY01 $K	FY02 $K	FY03 $K	FY04 $K
18	99001	INEEL	ID-2.1.06 ID-2.1.53 ID-2.1.54 ID-2.1.55 ID-2.1.63	21, 347, 2096	TRU, Sr and Cs Removal from INEEL Wastes	1150	500	0	0	0
19	99084	ORR	OR-TK-04 OR-TK-05	350, 1547, 2096	Solid-Liquid Separations—MVST	150	200	0	0	0
20	99048	Hanford	RL-WT015 RL-WT034-S RL-WT066	82, 2094	Testing and Prediction of Long Term Waste Glass Performance	1200	800	600	TBD	TBD
21	99009	INEEL	ID-2.1.24	21, 82, 347, 350, 881,	Integration/Optimization of High Activity Waste/Low Activity Waste Process Flowsheet	300	300	0	0	0
22	99052	Hanford ORR SRS WVDP	RL-WT021 OR-TK-02 SR99-2031 SR99-2037 OH-WV-908	2087, 2181, 2195	Technologies for Pit Operation Enhancement, Remote Operations/Maintenance and Disassembly	1600	2500	2050	TBD	TBD
23	99059	Hanford SRS	RL-WT060 RL-WT062 RL-WT051-S RL-WT054-S SR99-2028 SR99-2037 SR99-2041	1511, 2097, 2115, 2232, 2370	Hanford/SRS Waste Mixing and Mobilization	1900	3900	3400	TBD	TBD
24	99078	Hanford ORR SRS	RL-WT032-S OR-TK-04 SR99-2037 SR99-2044	279, 1547, 2236	Slurry Transfer and Tank Waste Mixing Monitors	500	500	250	TBD	TBD
25	99088B	SRS	SR99-2051 SR99-2049-S	233	Leaching and Treatment of Tc for Tank Closure	375	300	0	0	0
26	99018	INEEL	ID-2.1.36 ID-2.1.56	0	Removal of Mercury from NWCF Scrub Solutions	450	610	700	TBD	TBD
27	99046	Hanford INEEL	RL-WT09 ID-2.1.26 ID-2.1.43 ID-2.1.44	85, 860, 2119, 2235	Nested Array Fluidic and LDUA Sampler for Tank Waste	2740	2540	1680	TBD	TBD
28	99032	INEEL	ID-2.1.51	881	Develop Calcine Dissolution Kinetics for Solid/Liquid Equilibria	300	400	0	0	0
29	99031	INEEL	ID-2.1.50	0	Dry Solid Wastes Retrieval	340	450	300	TBD	TBD

Table C.1. (contd)

TFA Priority	TFA Response ID	Site	Site Need ID	OST Tech ID	TFA Technical Response Title	FY00 $K	FY01 $K	FY02 $K	FY03 $K	FY04 $K
30	99071	INEEL SRS	ID-2.1.27 SR99-2027	2091	Alternative Filtration Technologies	780	580	555	TBD	TBD
31	99049	Hanford	RL-WT016	82, 2094	Glass Monolith Surface Area	400	500	0	0	0
32	99072	SRS WVDP	SR99-2029 OH-WV-902	2009	Alternative HLW Canister Decontamination Techniques	0	400	750	3800	150
33	99050	Hanford	RL-WT017 RL-WT018	10, 523	Surface Barrier Testing	0	525	500	0	0
34	99014	INEEL	ID-2.1.29 ID-2.1.30	0	Remove/Treat Chlorides (LET&D/PEWE/Future Processes)	0	340	300	0	0
35	99060	Hanford SRS	RL-WT061 RL-WT046-S SR99-2051	82	Sequestering of Radionuclide Contaminant Migration	0	800	700	0	0
36	99064	Hanford INEEL	RL-WT01 RL-WT065 RL-WT031-S RL-WT052-S ID-2.1.16	127	Validate Analytical Procedures for Radioactive Waste Samples	0	1290	900	0	0
37	99055A	Hanford	RL-WT024 RL-WT037-S RL-WT038-S RL-WT041-S RL-WT049-S RL-WT050-S	233, 2096	Sludge Processing Parametric Studies	0	1350	1200	600	0
41	99062	Hanford	RL-WT063	1989	Saltcake Dissolution Retrieval	0	300	700	0	0
42	99058	Hanford	RL-WT029 RL-WT035-S RL-WT043-S RL-WT044-S RL-WT045-S RL-WT056-S RL-WT057-S	82	Data and Tools for Performance Assessment	0	650	500	0	0
45	99041	INEEL	ID-2.1.63	410, 841	Universal Solvent Process for TRU, Sr and Cs Removal	0	450	1250	500	0
46	99074	SRS	SR99-2031	0	Develop Remote Technology to Improve DWPF Operations	0	700	1700	1850	1350
47	99055B	Hanford	RL-WT023 RL-WT024	233, 2096, 2236	HLW Sludge Washing Monitor	0	350	350	0	0
49	99047A	Hanford	RL-WT013	2118	Vadose Zone Characterization Technologies	0	200	0	0	0

Appendix D – Major Milestones

Delivery of solutions to address site needs is a critical success measure of the TFA investments for solving EM problems. The nature of those problems and the technical solutions and schedules are discussed in Sections 2 and 6. To monitor progress toward technical objectives and increase probability of success, major milestones that represent significant progress, accomplishments, or interim steps towards delivery of technical solutions are identified from the overall list of program milestones. Progress toward delivery of solutions is measured in three areas:

- Delivery of data to support key decisions and to fill gaps in technical knowledge required to define the path to solution.
- Demonstration of technologies or concepts to support selection of technology alternatives or to demonstrate progress towards deployment of selected technologies.
- Deployment of technical solutions, including implementation of data in a baseline program and actual installation and operation of technologies in a tank, tank complex, or waste treatment facility.

Program guidance and technical task plans, including milestones, are developed to guide the evolution of the work and to measure progress at appropriate points in the implementation of the workscope. From those overall program milestones, a subset of key milestones is selected that represents critical activities, demonstrations, or deployments indicating significant progress toward or completion of delivering a technical solution. These key performance indicators and expected performance for each activity are defined in more detail in the Annual Performance Plan. The Annual Performance Plan is submitted at the start of the current execution year. Key activities and milestones are summarized in Table D.1. These activities are prioritized for funding in the TFA FY00 target budget case, but could be impacted by fiscal year budget holds or reductions.

Table D.1. Major Milestones

Problem Element	Need Number	Major Milestone Description - Site(s) Supported	FY
1.1.1.1		**Monitor Tank Integrity/Avoid Corrosion**	
1.1.1.1	RL-WT04	Deploy Final Design EN/MIT Corrosion Probe – Hanford	00
1.1.1.1	RL-WT04	Install Integrated Corrosion Probe Monitoring Station in Tank Farm Control Room - Hanford	01
1.1.1.1	ID-2.1.20	Demonstrate Remote Inspection for Tank Certification – Idaho	01
1.1.1.1	ID-2.1.20	Deploy Remote Inspection for WM-185 & WM-190 – Idaho	02
1.1.1.1	OR-TK-01	Deploy Corrosion Probe for Stainless Steel Tanks – ORR	01
1.1.1.1	SR99-2945	Deploy Combined EN/Raman Probe for Corrosion Monitoring - SRS	00
1.1.1.1	SR99-2035	Demonstrate Remote Tank Inspection System – SRS	01
1.1.2		**Ventilate Tank**	
1.1.2	ID-2.1.27	Demonstrate High Temperature HEPA Filters – Idaho	02
1.1.2	SR99-2027	Complete Testing of Prototype Commercial HEPA Filters – SRS	00
1.1.2	SR99-2027	Demonstrate HEPA Filters in Full-Scale Test Facility - SRS	01
1.1.2	SR99-2027	Deploy HEPA Filters on HLW Tank – SRS	01
1.1.3.2		**Sample Waste**	
1.1.3.2	ID-2.1.44	Certify LDUA Heel Sampler for RCRA/EPA Compliance - Idaho	00
1.1.3.2	RL-WT09 ID-2.1.26	Demonstrate RCRA Compliance of AEA Fluidic Sampling Technology– Hanford & Idaho	00
1.1.3.2	RL-WT09 ID-2.1.26	Complete Design and Authorize Fabrication of Hanford & Idaho Fluidic Samplers – Hanford & Idaho	01
1.1.3.2	RL-WT09 ID-2.1.26	Complete Cold Acceptance Testing and Deployment Planning for Fluidic Samplers – Hanford & Idaho	03
1.1.3.2	RL-WT09 ID-2.1.26	Deliver Hanford & Idaho Fluidic Samplers – Hanford & Idaho	02
1.1.3.2	ID-2.1.26	Deploy Fluidic Sampler at INTEC - Idaho	04
1.1.3.2	RL-WT09	Deploy Fluidic Sampler in DST – Hanford	04
1.1.3.3		**Analyze Waste**	
1.1.3.3	OR-TK-04	Demonstrate Dual Coriolis Slurry Monitor - ORR	00
1.1.3.3	OR-TK-04	Deploy Dual Coriolis Slurry Monitor at ORNL - ORR	01
1.1.3.3	SR99-2037	Deploy Rheology Monitor in SR Tank – SRS	00
1.1.3.3	SR99-2044	Deploy Slurry Monitor to Predict Pipeline Plugging - SRS	02
1.1.4		**Reduce Waste Volume**	
1.1.4	ID-2.1.16	Testing/Recommendations for Processing Waste Minimization – Idaho	00
1.1.4	ID-2.1.16	Install Waste Minimization Technology – Idaho	01
1.1.4	ID-2.1.56 ID-2.1.36	Demonstrate Mercury Removal on NWCF Scrub Solution and Dissolved Calcine Waste at Bench Scale - Idaho	01

Table D.1. (contd)

Problem Element	Need Number	Major Milestone Description - Site(s) Supported	FY
1.2.1.2		**Mobilize Bulk and Heel Wastes**	
1.2.1.2	RL-WT-060 SR99-2028	Provide Recommendations on Alternate Waste Mixing and Mobilization Systems – Hanford & SRS	00
1.2.1.2	RL-WT060	Complete Test/Demonstrate Extended Sludge Retrieval – Hanford	01
1.2.1.2	RL-WT060	Deploy Extended Sludge Retrieval System in AZ-101 – Hanford	03
1.2.1.2	RL-WT062	Deploy Variable Depth Transfer Pump in DST – Hanford	03
1.2.1.2	ID-2.1.50	Install Access Riser in Calcine Bin #1 – Idaho	01
1.2.1.2	ID-2.1.50	Complete Sampling of Calcine Bin #1 - Idaho	02
1.2.1.2	ID-2.1.50	Complete Preliminary Design of Calcine Bin Retrieval System	02
1.2.1.2	OR-TK-02	Deploy Heavy Waste Retrieval System in W-9 - ORR	00
1.2.1.2	OR-TK-02	Deploy Russian Pulsating Monitor - ORR	00
1.2.1.2	OR-TK-03	Deploy Mobile Fluidic Retrieval System in FFA Tanks - ORR	00
1.2.1.2	SR99-2028	Demonstrate Flygt Mixers at Full-Scale – SRS	00
1.2.1.2	SR99-2028	Deploy Flygt Mixers in Waste Tank – SRS	00
1.2.1.2	SR99-2037	Deploy Crawler in Tank 19 – SRS	00
1.2.1.2	SR99-2037	Complete Cold Verification Test of Russian Chemical Cleaning – SRS	00
1.2.1.2	SR99-3022	Deploy 1F Evaporator Sampling System – SRS	00
1.2.1.2	SR99-2037	Demonstrate Chemical Cleaning with Hot Waste – SRS	01
1.2.1.2	SR99-2041	Deploy Organic Layer Mixer in Process Tank – SRS	02
1.2.1.2	SR99-2041	Demonstrate Mixer Pump Operational Improvements – SRS	01
1.2.1.2	SR99-3022	Deploy 1F Evaporator Retrieval System – SRS	01
1.2.1.2	SR99-3022	Deploy CTS Pump Tank Retrieval System	01
1.2.1.2	SR99-2037	Deploy Chemical Cleaning in SR Tank – SRS	02
1.2.1.2	SR99-2037	Deploy Retrieval System for Obstructed Tanks – SRS	02
1.2.1.2	OH-WV-905	Fabricate and Test Advanced Waste Retrieval System in Tank 8D-1 – WVDP	00
1.2.1.2	OH-WV-905	Install Gamma Cameras in Tanks 8D-1 – WVDP	00
1.2.1.2	OH-WV-905	Deploy Characterization System for Final Tank Survey – WVDP	02
1.2.1.4		**Transfer Waste**	
1.2.1.4	OR-TK-02 RL-WT-023 SR99-2039	Recommend Waste Conditioning Processes for Sludge Transfer and Plugging Mitigation – ORR, Hanford, SRS	00
1.2.1.4	OR-TK-02	Deploy/Issue Performance Report on CPU Waste Conditioning – ORR	00
1.2.1.4	OR-TK-02	Deploy Waste Conditioning CPU for W-9 Waste Transfer – ORR	00
1.2.1.4	SR99-2039	Demonstrate Phase 1 Pipeline Unplugging Technologies – SRS	00
1.2.1.4	SR99-2039	Demonstrate Phase 2 Pipeline Unplugging Technologies – SRS	01
1.2.1.4	SR99-2039	Demonstrate Pipeline Inspection Technologies – SRS	02

Table D.1. (contd)

Problem Element	Need Number	Major Milestone Description - Site(s) Supported	FY
1.2.2.2		**Dissolve Waste**	
1.2.2.2	ID-2.1.51	Complete Dissolution Testing/Modeling on Radioactive Calcine – Idaho	00
1.2.2.2	ID-2.1.51	Conduct Pilot-Scale Calcine Dissolution Demonstration at INTEC- Idaho	01
1.2.2.3		**Prepare Retrieved Waste for Transfer and Pretreatment**	
1.2.2.3	RL-WT023	Issue Final Recommendations for Pipeline Transfers – Hanford	01
1.2.2.3	RL-WT023	Issue Recommendations for Chemical Pipeline Unblocking – Hanford	01
1.2.2.3	RL-WT063	Provide Saltcake Dissolution Data for ESP Model Validation – Hanford	01
1.2.2.3	SR99-2039	Issue Recommendations for Pipeline Transfers – SRS	02
1.2.2.3	SR99-2039	Issue Recommendations for Chemical Pipeline Unblocking – SRS	02
1.2.2.4		**Clarify Liquid Stream**	
1.2.2.4	OR-TK-05	Deploy Solid-Liquid-Separation for Cross-site Transfer – ORR	00
1.2.2.5		**Remove Radionuclides**	
1.2.2.5	ID-2.1.54, 55	Complete Long-Term Pilot Plant Tests for TRUEX/SREX - Idaho	00
1.2.2.5	ID-2.1.06	Demonstrate Tru, Sr, Cs Removal on Simulated Calcine – Idaho	00
1.2.2.5	ID-2.1.06	Demonstrate Tru, Sr, Cs Removal on Dissolved Zr-Calcine – Idaho	01
1.2.2.5	ID-2.1.06	Demonstrate Tru, Sr, Cs Removal on Dissolved Al-Calcine – Idaho	02
1.2.2.5	OR-TK-11	Process +100Kgal in Evaporator/Cesium Removal at MVST - ORR	00
1.2.2.5	SR99-1011	Deploy CIF Evaporator – SRS	00
1.2.2.5	SR99-2034	Pilot-Scale Demonstration of Salt Disposition Alternative - SRS	00
1.2.2.6		**Integrate Pretreatment & LLW Immobilization Technology Systems**	
1.2.2.6	ID-2.1.24	Recommend Initial Integrated Flowsheets for Process Options - Idaho	01
1.2.2.6	ID-2.1.24	Recommend Final Dynamic & Steady State Flowsheets - Idaho	03
1.2.3.1		**Process LLW**	
1.2.3.1	ID-2.1.28, 38	Issue Technical Baseline for Newly Generated Liquid Waste Flowsheet - Idaho	00
1.2.3.1	ID-2.1.28, 38	Deploy Grouting of INEEL Newly Generated Liquid Waste – Idaho	01
1.2.3.1	OR-TK-06	Demonstrate Sorbents for Grouted Waste Form - ORR	00
1.2.3.1	OR-TK-06	Recommend Stabilizers/Sorbents for Grouted Waste Form - ORR	02
1.2.3.2		**Process HLW**	
1.2.3.2	RL-WT06	Issue Report on Hanford Liquidus Temperature - Hanford	00
1.2.3.2	ID-2.1.57, 58	Complete Low-Temperature Glass Formulation Tests - Idaho	00
1.2.3.2	ID-2.1.58	Conduct Scaled-Melter Demonstration – Idaho	01
1.2.3.2	ID-2.1.57, 58	Complete High-Temperature Glass Formulation Tests - Idaho	02
1.2.3.2	ID-2.1.57, 58	Issue Recommendations on INEEL Glass Formulation - Idaho	02
1.2.3.2	SR99-2036	Recommend Melter Pour Spout/Riser Heater Improvements - SRS	00
1.2.3.2	SR99-2032	Issue Recommendations to Improve DWPF Durability Model - SRS	02
1.2.3.2	SR99-2036	Issue Requirements for Design/Control of 2nd Generation Melter - SRS	02

Table D.1. (contd)

Problem Element	Need Number	Major Milestone Description - Site(s) Supported	FY
1.3.1		**Close Tanks**	
1.3.1	ID-2.1.42	Submit INTEC Tank Closure Plan to DOE-ID - Idaho	00
1.3.1	ID-2.1.45	Demonstrate & Recommend Grout Formulation for Tank Closure - Idaho	01
1.3.1	ID-2.1.48	Demonstrate Tank Cleaning/Heel Treatment at INTEC - Idaho	02
1.3.1	OR-TK-09	Deploy MPI™ Grout Injection in OHF Tanks - ORR	00
1.3.1	OR-TK-09	Deploy MPI™ Grout Injection in Tank TH-4 - ORR	01
1.3.1	SR99-2051	Complete Treatability Studies for Tc Removal and Treatment - SRS	00
1.3.1	SR99-3022	Demonstrate Grout Injection for OBG Tank – SRS	00
1.3.1	SR99-2051	Demonstrate Tc Removal at Engineering Scale - SRS	01
1.3.2		**Disposal of LLW**	
1.3.2	RL-WT066	Issue Panel Recommendations on Long-Term Glass Performance - Hanford	00
1.3.2	RL-WT066	Define Acceptable Glass Composition Region for ILAW - Hanford	01
1.3.2	RL- WT066	Conduct Validation Tests on Acceptable Glass Composition - Hanford	02
1.4		**Decontamination and Decommissioning**	
1.4	RL-WT021	Select Remote Technologies for Pit Operation Enhancement - Hanford	00
1.4	RL-WT021	Deploy Technology for Remote Pit Operation Enhancement - Hanford	01
1.4	SR99-2037 SR99-2031	Recommend Remote Technologies for HLW Tank and DWPF Contaminated Equipment Maintenance and Disposal - SRS	00
1.4	SR99-2037	Specify Tank Component Maintenance/Disposal Equipment - SRS	01
1.4	SR99-2037	Cold Acceptance of Component Maintenance/Disposal System - SRS	02
1.4	SR99-2040 OH-WV-903	Recommend Methods for Glass Removal from Failed Melters, Waste Segregation, Size Reduction – SRS & WVDP	00
1.4	SR99-2040 OH-WV-903	Demonstrate Glass Removal Technologies – SRS & WVDP	01
1.4	SR99-2040 OH-WV-903	Specify Waste Segregation/Size Reduction Technology Requirements – SRS & WVDP	01
1.4	SR99-2040 OH-WV-903	Demonstrate Selected Glass Removal Technology at Full-Scale – SRS & WVDP	02
1.4	SR99-2040 OH-WV-903	Demonstrate Waste Segregation/Size Reduction Technologies – SRS & WVDP	03

Appendix E – Crosswalk Tables

This appendix provides four tables that helps the reader understand the relationships between TFA product lines, work packages, technical responses, and problem elements.

Table E.1 shows a crosswalk between the TFA work packages and its two technical budget formulation product lines. No administrative or management costs are included. For FY00, the totals do not consider any potential funding cut. The figures for FY01 relate to the approved FY01 Corporate Review Budget at the Target Request level.

Table E.2 numerically lists TFA Technical Responses and traces them to TFA Problem Elements and TFA Work Packages. Table E.3 lists Problem Elements and their related Technical Responses and Work Packages. Table E.4 shows the Problem Elements and Technical Responses contained in each Work Package.

Table E.1. Work Package Crosswalk to Product Lines

Budget Formulation Product Line	Work Package*	FY00 ($M)	FY01 ($M)
PL01 Tank Waste Retrieval and Closure	WT-01-01	$3.865	6.863
	WT-02-01	3.291	5.475
	WT-03-01	5.495	7.098
	WT-04-01	3.520	4.100
	WT-05-01	2.325	2.300
	S-WT-05-01	0.	0.850
	S-WT-06-01	0.	0.600
	S-WT-12-01	0.	0.800
	AR-WT-01-01	0.	0.168
	AR-WT-12-01	0.	0.
	Total	**$18.496**	**$28.254**
PL02 Tank Waste Pretreatment and Immobilization	WT-06-01	4.775	5.559
	WT-07-01	2.825	3.242
	WT-08-01	3.450	4.955
	WT-09-01	10.695	8.788
	WT-10-01	0.171	0.
	WT-11-01	0.300	0.
	S-WT-07-01	0.	0.600
	AR-WT-08-01	0.	1.093
	AR-WT-09-01	0.	0.336
	AR-WT-11-01	0.	0.
	Total	**22.216**	**24.573**
	Grand Total	**$40.712**	**$52.827**

*Work Packages
WT-01-01: Transfer Line/Unplugging/Feed Analysis
WT-02-01: Waste Immobilization and Retrieval
WT-03-01: Tank Integrity and Heel Retrieval
WT-04-01: Ancillary Tank Equipment Enhancements
WT-05-01: Tank Closure
WT-06-01: Enhanced Immobilization Productivity
WT-07-01: Product Acceptance and Canister Storage
WT-08-01: Solids Pretreatment
WT-09-01: Radionuclide Removal
WT-10-01: Immobilization Enhancements
WT-11-01: Constituent Separation and Analysis
WT-12-01: Closure Enhancements
S-WT-05-01: Technetium Chemistry
S-WT-06-01: Improved Waste Loading in HLW Glasses
S-WT-07-01: Long-Term Waste Glass Performance
S-WT-12-01: Moisture and Contaminant Transport
AR-WT-01-01: In Situ Waste Analysis
AR-WT-08-01: Waste Chemistry and Physical Properties for Processing
AR-WT-09-01: Radionuclides Separations
AR-WT-11-01: Chemical Analysis Methods Validation
AR-WT-12-01: Vadose Zone Characterization

Table E.2. Crosswalk of Technical Responses to Problem Elements and Work Packages

TFA Technical Response #	TFA Problem Element #	TFA Work Package #
99001	1.2.2.5	WT-09-01
99003	1.1.4	WT-04-01
99009	1.2.2.6	WT-06-01
99014	1.1.4	WT-09-01
99018	1.1.4	WT-08-01
99019	1.2.3.1	WT-07-01
99023	1.3.1	WT-05-01
99031	1.2.1.2	WT-02-01
99032	1.2.2.2	WT-11-01
99043	1.1.1.1	WT-04-01
99046	1.1.3	WT-01-01
99047A	1.3.1	WT-12-01
99048	1.3.2	WT-07-01
99049	1.3.2	WT-10-01
99050	1.3.2	WT-12-01
99052	1.4	WT-04-01
99054A	1.2.2.3	WT-08-01
99054B	1.2.2.3	WT-08-01
99055A	1.2.1.4	WT-08-01
	1.2.2.7	WT-11-01
99055B	1.2.2.7	WT-11-01
99057	1.2.1.5	WT-03-01
99058	1.3.2	WT-12-01
99059	1.2.1.2	WT-02-01
99060	1.3.1	WT-05-01
99062	1.2.1.2	WT-02-01
99064	1.1.3	WT-11-01
99067	1.2.1.2	WT-03-01
99068	1.2.3.2	WT-06-01
99070	1.2.2.5	WT-09-01
99071	1.1.2	WT-04-01
99072	1.3.3	WT-07-01

TFA Technical Response #	TFA Problem Element #	TFA Work Package #
99073	1.2.3.2	WT-06-01
99074	1.4	WT-10-01
99075	1.1.1.1	WT-03-01
99076	1.2.1.4	WT-01-01
99077	1.4	WT-06-01
99078	1.1.3	WT-08-01
99082	1.2.1.2	WT-02-01
99084	1.2.2.4	WT-08-01
99085	1.3.1	WT-05-01
99086	1.1.4	WT-09-01
	1.2.2.5	WT-09-01
99088B	1.3.1	WT-05-01
99098	1.2.2.5	WT-11-01
99099	1.2.3.2.4	WT-12-01
99100	1.1.3	WT-11-01
99101	1.3.1	WT-12-01
99102	1.3.1	WT-12-01
99103	1.2.3	WT-10-01
AR-WT-01-01	1.1.3	AR-WT-01-01
AR-WT-08-01	1.2.2.3	AR-WT-08-01
AR-WT-09-01	1.2.2.5	AR-WT-09-01
AR-WT-11-01	1.1.3	AR-WT-11-01
AR-WT-12-01	1.3.2	AR-WT-12-01
S-WT-05-01	1.3.1	S-WT-05-01
S-WT-06-01	1.3.2	S-WT-06-01
S-WT-07-01	1.3.2	S-WT-07-01
S-WT-12-01	1.3.2	S-WT-12-01

Table E.3. Crosswalk of Problem Elements to Technical Responses and Work Packages

TFA Problem Element #	TFA Technical Response #	TFA Work Package #
1.1.1.1	99043	WT-04-01
	99075	WT-03-01
1.1.2	99071	WT-04-01
1.1.3	99046	WT-01-01
	99064	WT-11-01
	99078	WT-08-01
	99100	WT-11-01
	AR-WT-01-01	AR-WT-01-01
	AR-WT-11-01	AR-WT-11-01
1.1.4	99003	WT-04-01
	99014	WT-09-01
	99018	WT-08-01
	99086	WT-09-01
1.2.1.2	99031	WT-02-01
	99059	WT-02-01
	99062	WT-02-01
	99067	WT-03-01
	99082	WT-02-01
1.2.1.4	99054A	WT-08-01
	99076	WT-01-01
1.2.1.5	99057	WT-03-01
1.2.2.2	99032	WT-11-01
1.2.2.3	99054A	WT-08-01
	99054B	WT-08-01
	AR-WT-08-01	AR-WT-08-01
1.2.2.4	99084	WT-08-01
1.2.2.5	99001	WT-09-01
	99070	WT-09-01
	99086	WT-09-01
	99098	WT-11-01
	AR-WT-09-01	AR-WT-09-01
1.2.2.6	99009	WT-06-01
1.2.2.7	99055A	WT-11-01
	99055B	WT-11-01
1.2.3	99103	WT-10-01
1.2.3.1	99019	WT-07-01
1.2.3.2	99068	WT-06-01
	99073	WT-06-01
1.2.3.2.4	99099	WT-12-01
1.3.1	99023	WT-05-01
	99047A	WT-12-01
	99060	WT-05-01
	99085	WT-05-01
	99088B	WT-05-01
	99101	WT-12-01
	99102	WT-12-01
	S-WT-05-01	S-WT-05-01
1.3.2	99048	WT-07-01
	99049	WT-10-01
	99050	WT-12-01
	99058	WT-12-01
	AR-WT-12-01	AR-WT-12-01
	S-WT-06-01	S-WT-06-01
	S-WT-07-01	S-WT-07-01
	S-WT-12-01	S-WT-12-01
1.3.3	99072	WT-07-01
1.4	99052	WT-04-01
	99074	WT-10-01
	99077	WT-06-01

Table E.4. Crosswalk of Work Packages to Problem Elements and Technical Responses

TFA Work Package #	TFA Problem Element #	TFA Technical Resp #
WT-01-01	1.1.3	99046
	1.2.1.4	99076
WT-02-01	1.2.1.2	99031
		99059
		99062
		99082
WT-03-01	1.1.1.1	99075
	1.2.1.2	99067
	1.2.1.5	99057
WT-04-01	1.1.1.1	99043
	1.1.2	99071
	1.1.4	99003
	1.4	99052
WT-05-01	1.3.1	99023
		99060
		99085
		99088B
WT-06-01	1.2.2.6	99009
	1.2.3.2	99068
		99073
	1.4	99077
WT-07-01	1.2.3.1	99019
	1.3.2	99048
	1.3.3	99072
WT-08-01	1.1.3	99078
	1.1.4	99018
	1.2.1.4	99054A
	1.2.2.3	99054A
		99054B
	1.2.2.4	99084
WT-09-01	1.1.4	99014
		99086
	1.2.2.5	99001
		99070
		99086
WT-10-01	1.2.3	99103
	1.3.2	99049
	1.4	99074
WT-11-01	1.1.3	99064
		99100
	1.2.2.2	99032
	1.2.2.5	99098
	1.2.2.7	99055A
		99055B
WT-12-01	1.2.3.2.4	99099
	1.3.1	99047A
		99101
		99102
	1.3.2	99050
		99058
S-WT-05-01	1.3.1	S-WT-05-01
S-WT-06-01	1.3.2	S-WT-06-01
S-WT-07-01	1.3.2	S-WT-07-01
S-WT-12-01	1.3.2	S-WT-12-01
AR-WT-01-01	1.1.3	AR-WT-01-01
AR-WT-08-01	1.2.2.3	AR-WT-08-01
AR-WT-09-01	1.2.2.5	AR-WT-09-01
AR-WT-11-01	1.1.3	AR-WT-11-01
AR-WT-12-01	1.3.2	AR-WT-12-01

Appendix F – Partner Programs

This appendix summarizes in tabular form (Table F.1) the TFA's known or expected support from other U.S. Department of Energy Office of Science and Technology development prorams for FY00 and FY01. Program management support costs are not considered.

Table F.1. TFA Partner Program Content ($x1,000)

TFA Response #	Project Name	FY00 Funding	FY01 Funding
CROSSCUTTING PROGRAMS			
Characterization, Monitoring, and Sensor Technology (CMST) Crosscutting Program			
99043	Raman pOH Sensor	65	0
99046	At-Tank Analysis System	600	600
99055B	Sludge Washing Monitors	0	350
99070	Salt Cesium Separation Monitors	300	200
99075	Tank Inspection and Integrity Techniques	300	300
99078	Slurry Transfer/Tank Waste Monitors	350	500
TOTALS		**1615**	**1950**
Efficient Separations and Processing (ESP) Crosscutting Program			
99001	Universal Solvent Process	250	350
99018	Mercury Removal	450	490
99070	Salt Cesium Separation Processes	250	200
99088B	Technetium Treatment and Removal	375	300
TOTALS		**1325**	**1340**
Robotics Crosscutting Program			
99046	Nested Array Fluidic and LDUA Sampler for Tank Waste	150	150
99052	Valve Box/Pump Pit Decontamination	1400	900
99067	Tank Heel Retrieval Technology	500	200
99074	Remote Technology to Improve DWPF Operations	0	200
99075	Tank Inspection and Integrity Techniques	200	200
99077	Remote Disassembly of HLW Melters	65	1250
TOTALS		**2315**	**2900**

Table F.1. (contd)

TFA Response #	Project Name	FY00 Funding	FY01 Funding
OTHER PARTNER PROGRAMS			
Accelerated Site Technology Deployment (ASTD) Program			
99043	High-Level Waste Tank Corrosion Control and Monitoring	280	0
99067	Tank Heel Retrieval Technology	400	0
99070	Salt Cesium Separation Process	3550	0
99077	Remote Disassembly of HLW Melters	1185	0
99082	Small, Horizontal, Limited Access Tank Retrieval	101	0
99084	Solid-Liquid Separations	150	100
99086	Modular Evaporator Ion Exchange System	1795	820
TOTALS		**7461**	**920**
Industry Programs			
99046	Nested Array Fluidic and LDUA Sampler for Tank Waste	0	400
99052	Valve Box/Pump Pit Decontamination	0	700
99059	Hanford/SRS Waste Mixing and Mobilization	0	1200
99071	Alternate Filtration Technologies	300	0
99074	Remote Technology to Improve DWPF Operations	0	500
99075	Tank Inspection and Integrity Techniques	400	400
99076	Waste Transfer Line Plugging Prevention and Unplugging	400	400
TOTALS		**1100**	**3600**
International Programs			
99001	Universal Solvent Extraction	200	0
99019	Conditioning and Immobilization of LAW	250	250
99032	Calcine Dissolution	100	100
99046	Nested Array Fluidic and LDUA Sampler for Tank Waste	1300	1190
99054A	Precipitate Properties and Kinetics	125	125
99059	SRS Pump Tank Mixer	100	0
99067	Chemical Tank Cleaning	100	100
TOTALS		**2175**	**1765**
TFA Support to University Programs			
99018	Mercury Removal	0	120
99049	Glass Monolith Surface Area	0	100
99054A	Feed Stability	250	175
99054B	Saltcake Dissolution	200	175
99055A	Sludge Processing Parametric Studies	0	150
99068	Develop Improved HLW Melters	125	100
99076	Transfer Line Plugging Prevention/Unplugging Methods	525	675
TOTALS		**1100**	**1495**
Basic and Applied Research			
S-WT-05-01	Technetium Chemistry	0	850
S-WT-06-01	Improved Waste Loading in HLW Glasses	0	600
S-WT-07-01	Long-Term Waste Glass Performance	0	600
S-WT-12-01	Moisture and Contaminant Transport	0	800
AR-WT-01-01	In Situ Waste Analysis	0	168
AR-WT-08-01	Waste Chemistry and Physical Properties for Processing	0	1093
AR-WT-09-01	Radionuclides Separations	0	336
AR-WT-11-01	Chemical Analysis Methods Validation	0	0
AR-WT-12-01	Vadose Zone Characterization	0	0
TOTALS		**0**	**7701**
Grand Totals of All Partner Programs		**17091**	**18417**

DOE's Environmental Management Science Program (EMSP) provides funding to conduct basic research addressing fundamental issues that may be critical to achieving EM's mission and goals. In the first three years of the program (1996, 1997, 1998), the EMSP awarded a total of 68 projects addressing HLW as the primary problem area. These projects are listed below. An additional 54 projects address other problem areas, but may be applicable to TFA requirements. The TFA is monitoring the progress of those projects that are specifically applicable to site science and technology needs, including

- technetium chemistry
- chemical and physical property measurement
- radionuclide separations
- waste chemistry and physical properties
- improving HLW glass waste forms
- validating waste form performance
- characterizing moisture and contaminant concentrations and transport in the vadose zone beneath tanks and disposal facilities.

The 1999 EMSP awards address subsurface contamination in the vadose zone and are of particular interest to the Subsurface Contamination Focus Area. The TFA will evaluate these most recent awards for potential application to tank closure waste disposal technology needs.

1998 EMSP Awards Addressing HLW

- *Actinide-Aluminate Speciation in Alkaline Radioactive Waste* – Los Alamos National Laboratory
- *Electrically Driven Technologies for Radioactive Aerosol Abatement* – Oak Ridge National Laboratory
- *Ion Recognition Approach to Volume Reduction of Alkaline Tank Waste by Separation and Recycle of Sodium Hydroxide and Sodium Nitrate* – Oak Ridge National Laboratory
- *Detection and Characterization of Chemicals Present in Tank Waste* – Oak Ridge National Laboratory
- *Solution Effects on Cesium Complexation with Calixarene - Crown Ethers from Liquid to Supercritical Fluids* – University of Idaho
- *Developing a Fundamental Basis for the Characterization, Separation, and Disposal of Plutonium and Other Actinides in High Level Radioactive Waste: The Effect of Temperature and Electrolyte Concentrations on Actinide Speciation* – Washington State University
- *Physical, Chemical and Structural Evolution of Zeolite-Containing Waste Forms Produced from Metakaolinite and Calcined HLW* – Pennsylvania State University
- *Speciation, Dissolution, and Redox Reactions of Chromium Relevant to Pretreatment and Separation of High-Level Wastes* – Pacific Northwest National Laboratory
- *Actinide-Specific Interfacial Chemistry of Monolayer Coated Mesoporous Ceramics* – Pacific Northwest National Laboratory
- *Numerical Modeling of Mixing of Chemically Reacting, Non-Newtonian Slurry for Tank Waste Retrieval* – University of Minnesota

- *Complexants for Actinide Element Coordination and Immobilization* – Argonne National Laboratory
- *Characterization of Actinides in Simulated Alkaline Tank Waste Sludges and Leach Solutions* – Argonne National Laboratory
- *Mechanisms and Kinetics of Organic Aging in High-Level Nuclear Wastes* – Pacific Northwest National Laboratory
- *Electroactive Materials for Anion Separation - Technetium from Nitrate* – Pacific Northwest National Laboratory
- *Rapid Migration of Radionuclides Leaked from High-Level Waste Tanks: A Study of Salinity Gradients, Wetted Path Geometry and Water Vapor Transport* – Pacific Northwest National Laboratory
- *Precipitation and Deposition of Aluminum-Containing Phases in Tank Wastes* – Pacific Northwest National Laboratory
- *Correlation of Chemisorption and Electronic Effects for Metal/Oxide Interfaces: Transducing Principles for Temperature-Programmed Gas Microsensors* – National Institute of Standards - Boulder
- *Modeling of Spinel Settling in Waste Glass Melter* – Pacific Northwest National Laboratory
- *Mass Spectrometric Fingerprinting of Tank Waste Using Tunable, Ultrafast Infrared Lasers* – Vanderbilt University
- *Millimeter-Wave Measurements of High Level and Low Activity Glass Melts* – Massachusetts Institute of Technology

1997 EMSP Awards Addressing HLW

- *Chemical Speciation of Inorganic Compounds Under Hydrothermal Conditions* - University of Washington
- *Development of Advanced Electrochemical Emission Spectroscopy for Monitoring Corrosion in Simulated DOE Liquid Waste* - Pennsylvania State University
- *Dynamic Effects of Tank Waste Aging on Radionuclide-Complexant Interactions* - Los Alamos National Laboratory
- *Foaming in Radioactive Waste Treatment and Immobilization Processes* - Illinois Institute of Technology
- *Fundamental Chemistry, Characterization, and Separation of Technetium Complexes in Hanford Waste* - Los Alamos National Laboratory
- *High Temperature Condensed Phase Mass Spectrometric Analysis* - Idaho National Engineering and Environmental Laboratory
- *Ion-Exchange Processes and Mechanisms in Glasses* - Pacific Northwest National Laboratory
- *Mechanics of Bubbles in Sludges and Slurries* - Pacific Northwest National Laboratory
- *Mechanism of Pitting Corrosion Prevention by Nitrite in Carbon Steel Exposed to Dilute Salt Solutions* - Westinghouse Savannah River Company
- *Mineral Surface Processes Responsible for the Decreased Retardation (or Enhanced Mobilization) of* ^{137}*Cs from HLW Tank Discharges* - Pacific Northwest National Laboratory

- *New Silicotitanate Waste Forms: Development and Characterization* - Pacific Northwest National Laboratory
- *Optically-Based Array Sensors for Selective In Situ Analysis of Tank Waste* - Oak Ridge National Laboratory
- *Particle Generation by Laser Ablation in Support of Chemical Analysis of High Level Mixed Waste from Plutonium Production Operations* - Washington State University
- *Phase Chemistry of Tank Sludge Residual Components* - Sandia National Laboratories
- *Potential-Modulated Intercalation of Alkali Cations into Metal Hexacyanoferrate Coated Electrodes* - University of Washington
- *Radiation Effects on Transport and Bubble Formation in Silicate Glasses* - Argonne National Laboratory
- *Reactivity of Peroxynitrite: Implications for Hanford Waste Management and Remediation* - Brookhaven National Laboratory
- *Removal of Technetium, Carbon Tetrachloride, and Metals from DOE Properties* - Pennsylvania State University
- *Research Program to Investigate the Fundamental Chemistry of Technetium* - Lawrence Berkeley Laboratory
- *Stability of High-Level Waste Forms* - Oak Ridge National Laboratory
- *Synthesis and Characterization of Templated Ion Exchange Resins for the Selective Complexation of Actinide Ions* - Johns Hopkins University Applied Physics Laboratory
- *The Influence of Radiation and Multivalent Cation Additions on Phase Separation and Crystallization of Glass* - University of Arizona
- *Thermospray Mass Spectrometry Ionization Processes Fundamental Mechanisms for Speciation and Characterization of Organic Complexants in DOE Wastes* - Oak Ridge National Laboratory

1996 EMSP Awards Addressing HLW

The following 30 TFA-related tasks were approved by DOE in FY96:

- *Acid-Base Behavior in Hydrothermal Processing of Wastes* - University of Texas at Austin
- *Acoustic Probe for Solid-Gas-Liquid Suspensions* - Syracuse University
- *Analysis of Surface Leaching Processes in Vitrified High-Level Nuclear Wastes Using In-Situ Raman Imaging and Atomistic Modeling* - University of Florida
- *Architectural Design Criteria for F-Block Metal Ion Sequestering Agents* - Pacific Northwest National Laboratory
- *Chemical Decomposition of High-Level Nuclear Waste Storage/Disposal Glasses Under Irradiation* - Naval Research Laboratory
- *Chemical Speciation of Strontium, Americium, and Curium in High Level Waste: Predictive Modeling of Phase Partitioning During Tank Processing* - Pacific Northwest National Laboratory
- *Collodial Agglomerates in Tank Sludge: Impact on Waste Processing* - Pacific Northwest National Laboratory
- *Design and Development of a New Hybrid Spectroelectrochemical Sensor* - University of Cincinnati

- *Design and Synthesis of the Next Generation of Crown Ethers for Waste Separations: An Inter-Laboratory Comprehensive Proposal* - Oak Ridge National Laboratory
- *Determination of Transmutation Effects in Crystalline Waste Forms* - Argonne National Laboratory (two tasks)
- *Enhanced Sludge Processing of HLW: Hydrothermal Oxidation of Chromium, Technetium, and Complexants by Nitrate* - Los Alamos National Laboratory
- *f-Element Ion Chelation in Highly Basic Media* - University of New Mexico
- *High Fluence Neutron Source for Nondestructive Characterization of Nuclear Waste* - Los Alamos National Laboratory
- *Ionizing Radiation Induced Catalysis on Metal Oxide Particles* - Pacific Northwest National Laboratory
- *Imaging and Characterizing the Waste Materials Inside an Underground Storage Tank Using Seismic Normal Modes* - Massachusetts Institute of Technology
- *Improved Analytical Characterization of Solid Waste-Forms by Fundamental Development of Laser Ablation Technology* - Lawrence Livermore National Laboratory
- *Interfacial Radiolysis Effects in Tank Waste Speciation* - Pacific Northwest National Laboratory
- *Investigation of Microscopic Radiation Damage in Waste Forms Using ODNMR and AEM Techniques* - Argonne National Laboratory
- *Investigation of Novel Electrode Materials for Electrochemically-Based Remediation of High- and Low-Level Mixed Wastes in the DOE Complex* - California Institute of Technology
- *Microstructural Properties of High Level Waste Concentrates and Gels with Raman and Infrared Spectroscopies* - Los Alamos National Laboratory
- *Mixing Processes in High-Level Waste Tanks* - University of California at Berkeley
- *On-Line Slurry Viscosity and Concentration Measurement as a Real-Time Waste Stream Characterization Tool* - University of California at Davis
- *Polyoxometalates for Radioactive Waste Treatment* - Georgetown University
- *Processing of High Level Waste: Spectroscopic Characterization of Redox Reactions in Supercritical Water* - Furman University
- *Quantifying Silica Reactivity in Subsurface Environments: Controls of Reaction Affinity and Solute Matrix on Quartz and SiO_2 Glass Dissolution Kinetics* - Georgia Institute of Technology
- *Radiation Effects in Nuclear Waste Materials* - Pacific Northwest National Laboratory
- *Radiation Effects on Materials in the Near-Field of Nuclear Waste Repository* - University of New Mexico
- *Studies Related to Chemical Mechanisms of Gas Formation in Hanford High-Level Nuclear Wastes* - Georgia Institute of Technology
- *Superconducting Open-Gradient Magnetic Separation for the Pretreatment of Radioactive or Mixed Waste Vitrification Feeds* - Argonne National Laboratory
- *The NOx System in Nuclear Waste* - Argonne National Laboratory

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

The U.S. Department of Energy (DOE) stores radioactive waste in tanks at five sites:

- Hanford Site, Washington
- Idaho National Engineering and Environmental Laboratory (INEEL), Idaho
- Oak Ridge Reservation (ORR), Tennessee
- Savannah River Site (SRS), South Carolina
- West Valley Demonstration Project (WVDP), New York.

The Tanks Focus Area (TFA) develops 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 at the five DOE sites. This appendix provides a brief summary of the sites, the wastes, the waste storage environments, regulatory drivers, and major tank waste remediation milestones for these five DOE sites.

G.1 Hanford Site

The Hanford Site is a 560-mi^2 former plutonium production site in the southeastern part of Washington State. It lies just north of where the Snake and Yakima rivers meet the Columbia River, and about 25 mi north of the Oregon border. This area is dry, flat land surrounded by hills. In January 1943, Hanford was selected for the nation's first industrial-scale production site for plutonium.

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 diversified to include technology development, waste management, and environmental restoration. Hanford 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 1995b). Hanford's tank farms are located in the 200 East and 200 West Areas (see Figure G.1). In addition to cleaning up tanks, site 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 (Gephart and Lundgren 1998).

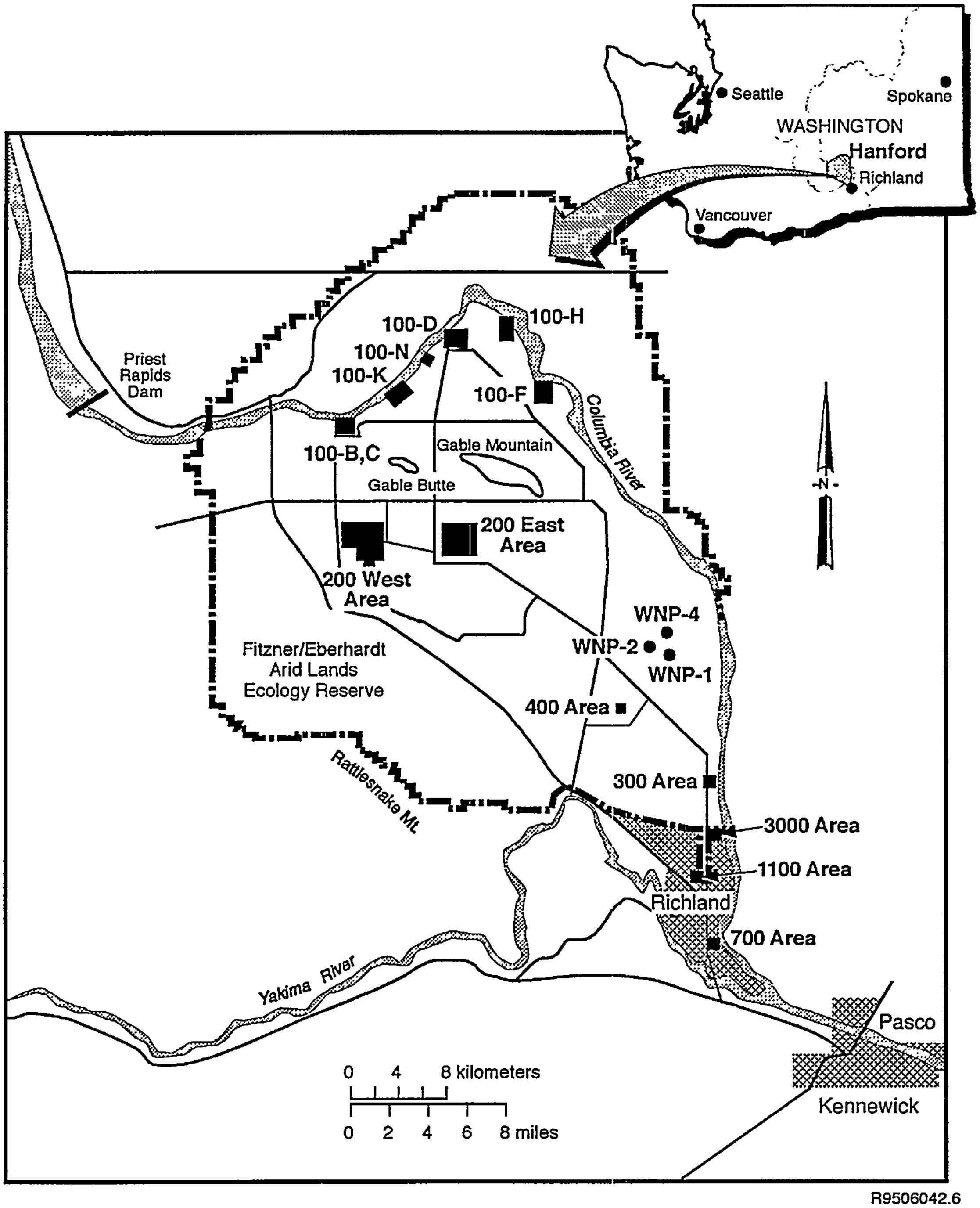

Figure G.1. Hanford Site and Major Facilities

G.1.1 Characteristics of Hanford Tank Waste

The tank waste consists of high-level waste (HLW), transuranic (TRU) waste, and low-level waste (LLW). The total activity of the 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). Cesium-137 is soluble and in the supernate, and strontium-90 is largely contained in the sludge. 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 supernate contains large amounts of dissolved sodium salts, especially nitrates and nitrites.

G.1.2 Waste Generation at the Hanford Site

The chemical and physical processes for separating plutonium from uranium and the rest of the chemical waste generated in Hanford plants changed over the years. Therefore, the composition of the waste piped to the tanks also varied.

First, uranium fuel in the form of uranium metal was surrounded by a thin-walled metal covering (called cladding) of aluminum and later Zircaloy (mostly zirconium). This was placed in one of the nine nuclear reactors built between 1943 and 1963 on the northern edge of the Site along the Columbia River. The cladding prevented chemical reactions between the uranium and cooling water, while also preventing radioactive fission products from getting into the reactor's cooling water.

The uranium fuel (uranium-238) was irradiated by being exposed to and capturing low-energy neutrons emitted by uranium-235, as it underwent fission. Irradiating uranium-238 created more complex elements, such as plutonium-239. The fission of uranium-235 also created short-lived (less than a second) to long-lived (decades to millions of years) radioactive elements called fission products. The irradiated fuel was then transported in specially shielded rail cars to a reprocessing facility in the center of the Hanford Site, away from the Columbia River.

From the 1940s to the mid-1950s, five of these reprocessing facilities were built: T Plant, B Plant, U Plant, the Reduction and Oxidation (REDOX) Plant, and the Plutonium and Uranium Extraction (PUREX) Plant. From 1944 to 1989, Hanford facilities reprocessed 110,000 ton of uranium fuel — 74% of this reprocessing took place at the PUREX Plant.

On average, approximately 1.5 lb of plutonium-239 was chemically separated from each ton of reprocessed uranium fuel. Over the years, several separation processes were used. Plutonium was recovered and purified from the dissolved uranium and fission products in the early Hanford plants by a bismuth phosphate chemical precipitation process, and in later plants by two solvent extraction processes.

The first solvent extraction process used methyl isobutyl ketone (also known as hexone) as the organic solvent with aluminum nitrate added to improve uranium and plutonium separation from other radionuclides. This process was called the REDOX process. The first large-scale operation of the REDOX process began at Hanford in 1952 in the S Plant (also called the REDOX Plant). It offered several advantages over the bismuth phosphate process by 1) reducing waste volume, 2) recovering both uranium and plutonium, and 3) allowing continuous plant operations.

An improved solvent-extraction process called the PUREX process was subsequently developed. It differed from REDOX in the use of tributyl phosphate as the organic solvent and nitric acid as a salting agent. The PUREX process was first used at the site near Savannah River Site in 1954. In 1956, the process was used at Hanford in the A Plant (also called the PUREX Plant). It offered several advantages compared to the REDOX process including 1) increased reduction in waste volume, 2) greater flexibility in process control, 3) less fire hazard, and 4) decreased operation costs.

The solvent extraction processes created two liquid waste streams. The extractant stream contained plutonium and uranium. This stream went through several chemical processing steps to separate the plutonium and uranium from each other, from other chemicals, and from other fission products. The second stream was called raffinate. This was considered waste and discharged to the tanks. It contained about 99% of all the fission products, such as cesium and strontium. Some waste was also generated from the chemical separation processes of the extractant stream. Waste considered HLW was piped to the underground tanks. Less radioactive waste was discharged to the soil through cribs and trenches.

These processes generated liquid wastes containing large quantities of contaminated nitric acid, chemicals, fission products, and miscellaneous waste. Before being piped to an underground storage tank, these highly radioactive wastes were mixed with sodium hydroxide to neutralize the acidic liquids (pH 1-4), making the solutions strongly basic (pH 10-14).

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 54 Mgal of wastes, in a variety of forms. Some waste 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.

G.1.3 Storage Tanks at the Hanford Site

Hanford's tanks are cylindrical reinforced concrete structures with inner carbon-steel liners. The tanks are split into two groups based on their design: 149 tanks have a single carbon-steel liner and 28 tanks have two steel liners separated by a space called the annulus. The domes of the single-shell tanks are made of concrete without a steel inner liner. The double-shell tanks are completely enclosed by steel and reinforced by a concrete shell. Both single-shell tanks and double-shell tanks are covered with about 10 ft of soil and gravel.

These tanks contain about 200 MCi of radioactivity (mostly cesium-137 and strontium-90) and 240,000 ton of chemicals (mostly sodium nitrate). This is 50% of the radioactivity and 60% of the chemical waste at the Hanford Site.

In the 200 East and 200 West Areas, the tanks were built in 18 groups called tank farms. The farms contain from 2 to 16 tanks and hold different amounts of waste. The farms contain underground pipes so the waste can be pumped between tanks, between tank farms, from different facilities, and between the 200 East and 200 West Areas. The farms also include equipment that is used to route the waste, such as diversion boxes and valve pits.

Because of the large volume of HLW produced, tank space was very limited. Various treatments were used to reduce the amount of liquid. The first tank waste concentrators went into operation in 1951. They were steam-heated pot-like evaporators operated at atmospheric pressure outside the tanks. Waste was piped from the single-shell tanks into these concentrators to partially boil down the liquids.

Operation of the 242-S (located in 200 West Area near the REDOX Plant) and 242-A Evaporator-Crystallizers (located in 200 East Area near PUREX Plant) began in 1973 and 1977, respectively. These evaporators were used to boil off water from the tank liquids at a much larger scale than previous techniques. This was accomplished by pumping liquids from the tanks into the evaporator. Evaporation was carried out until a thick slurry was created containing about 30% by weight of solids. The slightly hot, concentrated slurry was then piped back into a tank where it cooled, crystallized, and/or settled to the tank's bottom. Between 1950 and 1995, approximately 200 Mgal of liquids were evaporated from Hanford's tank waste.

Another early Hanford technique involved heating the tank's liquids from inside the tank. One approach used an electric heater inserted directly into the waste. The heated waste was then circulated into other tanks. A second approach involved circulating hot air in an individual tank through a perforated pipe.

Precipitating and settling otherwise soluble radioactive chemicals was another method; this made the tank's upper liquid layer less radioactive and less hazardous so it could be disposed of in the ground. From 1954 to 1957, radioactive cesium-137 was precipitated out of the solution by adding potassium ferrocyanide and nickel sulfate to waste piped to the Uranium Recovery Plant. After the cesium settled out, the less radioactive liquid was sent to cribs (a crib is like a shallow buried tile field used to dispose of liquid wastes). With the tank liquids lowered, more reprocessing waste could be put in the tanks. Approximately 150 tons of ferrocyanide were added to some tanks in this process.

G.1.3.1 Single-Shell Tanks

The single-shell tanks were built from 1943 to 1964 to hold the liquid radioactive waste created by the production and separation of plutonium. The 149 single-shell tanks were built in four sizes:

- 16 have a capacity of 55,000 gal
- 60 have a capacity of 530,000 gal
- 48 have a capacity of 758,000 gal
- 25 have a capacity of 1 Mgal.

Over the years, the design of the single-shell tanks changed to better accommodate the waste being stored and to reduce the occurrence of metal corrosion and cracking. Alterations included adding equipment to handle self-boiling waste, increasing size, and changing the bottom to a flat surface instead of a bowl shape.

Another change was the addition of a grid of drain slots beneath the steel liner. The grids were designed to collect leakage and divert it to a leak detection well. Further, several 530,000-gal and 758,000-gal single-shell tanks were built in cascades of three or four tanks. These cascading tanks were connected with piping at different levels. Thus, when one tank filled to the level of the pipe, waste would flow through the pipe to the next tank. This allowed the solid contents of the tank waste to settle to the bottom. The liquid waste that went to the next tank had less solids and less radioactivity (mostly in the form of cesium; strontium settled out in the solids).

G.1.3.2 Double-Shell Tanks

Double-shell tanks were built to provide more tank space. Liquid from the single-shell tanks was pumped into the newer, safer double-shell tanks. This left the single-shell tanks containing mostly saltcake and sludge, with some liquids. From then on, the double-shell tanks received supernatant liquids pumped directly from operating reprocessing plants such as the PUREX Plant and supernatant liquids pumped from single-shell tanks. The double-shell tanks were built from 1968 to 1986 (Figure G.2) in two sizes:

- 4 tanks have a capacity of 1.0 Mgal
- 24 tanks have a capacity of 1.16 Mgal.

Generally, these tanks contain liquids and thicker slurries. Some tanks also contain a bottom layer of sludge. Approximately 75% of the double-shell tank waste consists of waste pumped from single-shell tanks to minimize the potential for leakage from those tanks.

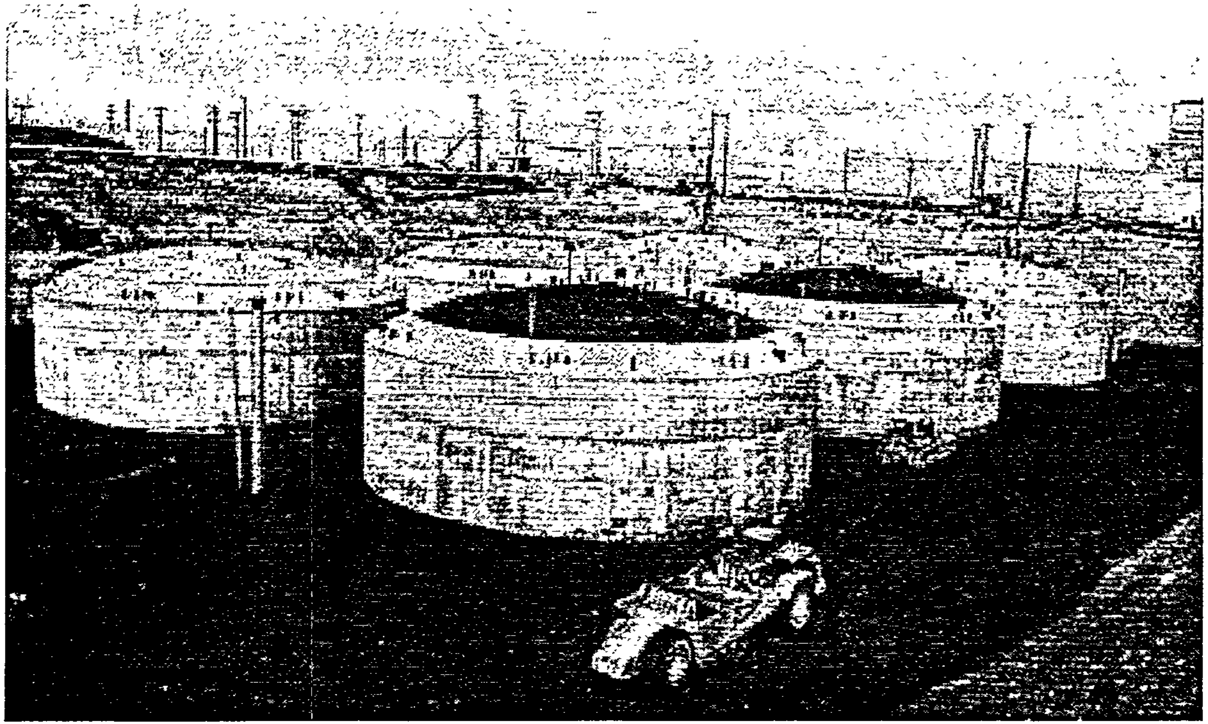
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Figure G.2. Hanford Double-Shell Tanks Under Construction

G.1.4 Regulatory Drivers for the Hanford Site

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).
- Hanford Federal Facility Agreement and Consent Order 1996 Amendments (DOE-RL 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 Privatization Request for Proposal No. DE-RP06-96RL13308 [DOE-RL 1996c]). The change did not affect major milestones for the processing of tank waste, except that low-activity wastes will be treated by 2024 instead of 2028.

- Changes to Hanford Federal Facility Agreement and Consent Order Milestone M-44-00, Tank Waste Characterization. Submitted for public comment on July 15, 1997. This change package eliminates requirements for sampling a predetermined number of tanks and instead bases characterization on needs identified by the programs.
- Environmental Impact Statement (EIS) for the Tank Waste Remediation System (TWRS) (DOE-RL and Ecology 1996a). The EIS provides information that has the potential to rebaseline tank waste remediation at Hanford. 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, signed in February 1997, stated that the phased approach was the best path forward for treating tank wastes.
- Draft Hanford Remedial Action Environmental Impact Statement and Comprehensive Land Use Plan (DOE-RL 1996). DOE has developed a land use plan for Hanford that is included in the EIS for Hanford remedial actions. The EIS was 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.
- DOE/Ecology Retrieval Performance Objectives Memorandum of Understanding (MOU). The MOU specifies cost, risk and safety as some of the key parameters that must be evaluated in defining the tank waste end-state.
- Project Hanford Management Contract. Fluor Daniel Hanford, Inc., and its contractors manage and integrate remediation of the Hanford Site. The contract 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 were to be completed by July 1995 and in other tanks by July 1996. These deadlines have not been met.
- Integrated Vadose Zone Program. This program was established by TWRS to assess risk during waste retrieval, treatment, and closure from leaking tanks.

Richland Accelerated Cleanup Plan (DOE-RL 1997). The plan describes how the site will meet existing cleanup agreements. Stakeholders have demanded that the goals of existing cleanup agreements not be compromised. Hanford completes vitrification of tank waste in 2028.

G.1.5 Milestones for the Hanford Site

Selected Hanford Site milestones are shown in Table G.1.

Table G.1. Hanford Site Milestones

Milestone Title	Completion Date
Construct initial low- and high-activity immobilization plants	2002
Treat and immobilize 6 to 13% of tank waste	2011
Immobilize low-activity waste	2024
Immobilize remaining tank waste	2028
Close all tanks	2032

G.2 Idaho National Engineering and Environmental Laboratory

The 890-mi^2 Idaho National Engineering and Environmental Laboratory (INEEL) is located in eastern Idaho on a generally flat plain (see Figure G.3). The site was founded in 1949 as the National Reactor Testing Station. The first facilities, built in the early 1950s, supported the Experimental Breeder Reactor where the first usable amounts of nuclear-generated electricity were produced. Over time, a variety of other reactors were built here. A prototype for the reactor used in the first nuclear-powered submarine was developed. Also, three of the nation's commercial power reactor designs (the pressurized water reactor, the boiling water reactor, and the liquid metal cooled breeder reactor) were built and demonstrated.. In total, 52 separate reactors have been built and operated at the site. All but one of these reactors has been decommissioned.

G.2.1 Characteristics of INEEL Tank Waste

As of August 1998, the total tank waste inventory stood at about 1.4 Mgal consisting of sodium-bearing waste generated from activities incidental to reprocessing, such as facility decontamination. In general, the tank waste at the Idaho Nuclear Technology and Engineering Center (INTEC, formerly the Idaho Chemical Processing Plant) is rather different from the waste at the other DOE tank sites. The INTEC waste is characterized by large concentrations of nitrates and dissolved metals such as aluminum, potassium, and sodium

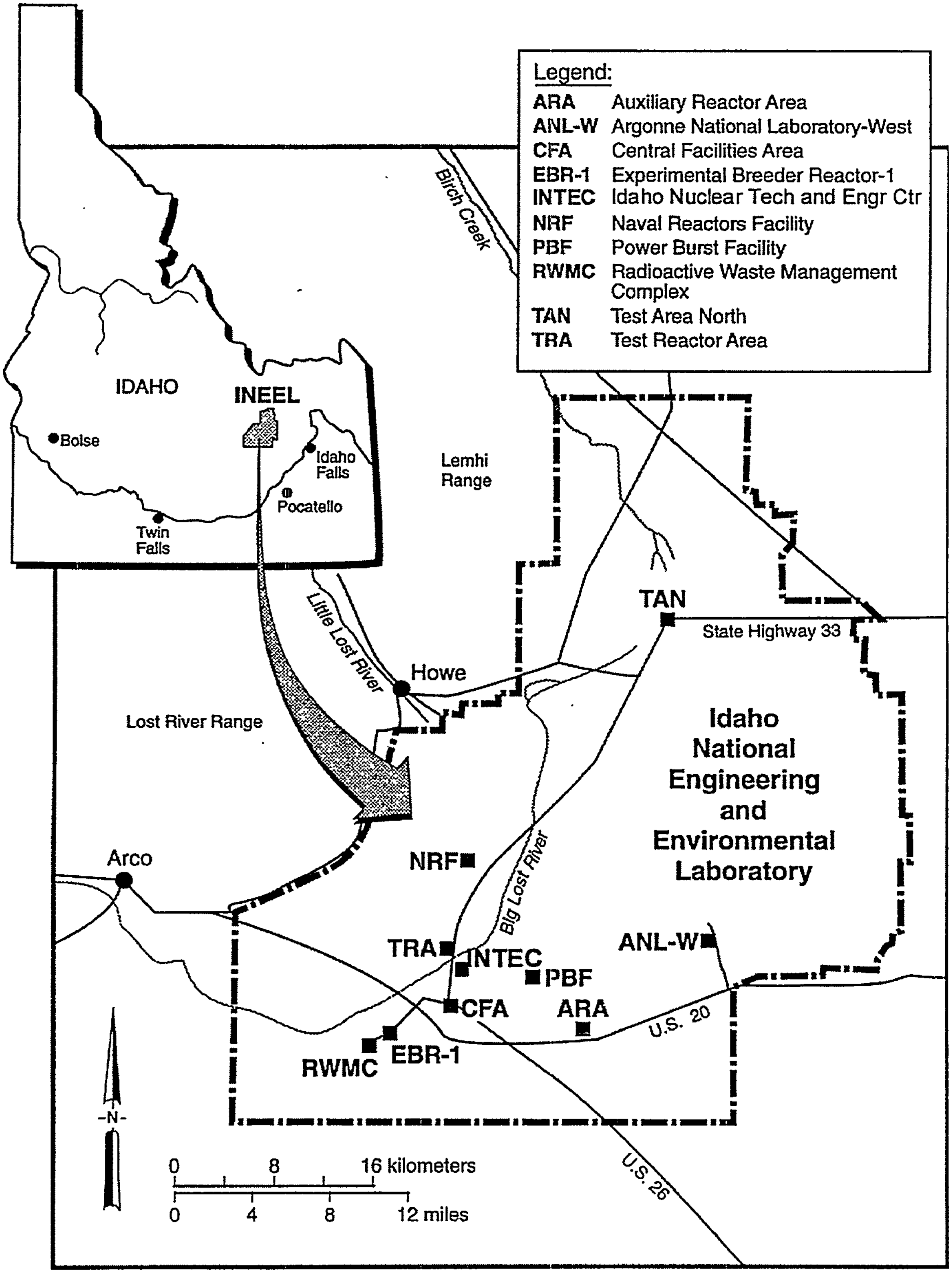

Figure G.3. Idaho National Engineering and Environmental Laboratory and Major Facilities with small concentrations of sulfates, chlorides, and heavy metals such as chromium and nickel (Rouse et al. 1993, p. 6-21). The tank waste is extremely acidic, with a pH of less than 1 (Rouse et al. 1993, p. 6-19). The liquid waste has a density of 1.1 to 1.3 g/cm^3 (Rouse et al. 1993, p. 6-19). The waste is composed predominantly of nitric acid and sodium nitrate. Small amounts of fission products and transuranic elements are also in the waste. Some of the major constituents of waste by molarity (nominal) are nitrate, 4.5; sodium, 1.5; acid, 1.3; aluminum, 0.57, and potassium, 0.17. The very basic (high pH) waste in the other site's tanks caused many radioactive and nonradioactive metals to segregate into a complex chemical and physical mixture of liquids, slurries, and sludges. In contrast, the metals and other dissolved material in INTEC's acidic tank waste remain in solution. Other than a few inches of accumulated solids on the bottom of the tanks, the liquid is clear to the bottom of the tanks. This simplifies waste characterization and retrieval compared to other DOE tank sites.

INTEC's tank waste has been divided into two categories: high-level liquid waste and sodium-bearing waste. All of the high-level liquid waste resulting from the dissolution and processing of spent nuclear fuel has been calcined (see calcination description at G.2.3) and is stored in bin sets. Only sodium-bearing waste remains in storage in the tank farm.

G.2.2 Waste Generation at INEEL

Several waste management facilities were built at INEEL. A key facility is INTEC. Building began on this facility in 1951, and it was operating by 1953. This plant received, stored, and reprocessed spent nuclear fuel for the recovery of uranium-235. It is one of eight reprocessing facilities built in the DOE complex. [The others were build at Hanford (five plants) and SRS (two plants).] Most reprocessing was performed on zirconium-clad uranium fuel used in the Navy's propulsion reactors. Significant quantities of fuel clad in aluminum, stainless steel, and graphite were also reprocessed. DOE terminated reprocessing activities in 1992.

Reprocessing began with the receipt of spent reactor fuel; it arrived in shielded casks via truck or rail. The spent fuel was removed from the casks and stored under water at the Fuel Receiving and Storage Building. If the fuel was not suitable for underwater storage due to corrosion or reactivity concerns, it was stored in dry storage facilities.

Next, the fuel was dissolved in either hydrofluoric acid for zirconium-clad fuel or nitric acid for aluminum- and stainless steel-clad fuel. An electrolytic process was employed to speed the dissolution of the stainless steel. The fluoride solutions were complexed with aluminum nitrate so the follow-on processing steps could be carried out with the same equipment used for the other fuel types. At this point the solution consisted of uranyl nitrate and nitrated fission products such as cesium-137, strontium-90, and transuranic elements. For graphite fuel, combustion preceded dissolution. Small quantities of other nuclear fuels were custom processed in specialized on-site hot cell laboratories.

The solution was then treated using a modified PUREX process. This process produced a uranyl nitrate solution and waste solutions. The uranyl nitrate solution was evaporated and denitrated into uranium trioxide granules. These granules were shipped to the Y-12 Plant at the ORR in Tennessee, to be processed into new reactor fuel (Rouse et al. 1993, p. 6-13).

The highly radioactive and chemically concentrated liquid (called raffinate) was collected and transferred to the tank farm, which consists of 11 underground storage tanks, to await further treatment. Low-level liquid wastes from incidental processes were collected and concentrated in an evaporator, which is still in operation. Concentrates from this evaporator are transferred to the tank farm and the evaporator overheads are superheated, filtered, and discharged to the atmosphere through the plant stack.

From FY98 through the year 2000, baseline waste generation modeling shows that site activities will generate about 515,000 gal of sodium-bearing waste. Operation of the calciner will generate about 92,000 gal of calcined solids. About 15,000 gal of sodium-bearing waste are added to the tanks each month from facility decontamination and decommissioning, off-gas system operation, and spent nuclear fuel storage. No HLW has been added to the tanks since reprocessing was terminated in 1992 (TFA 1996, p. A.13). There is no projected generation of HLW at INTEC in the future; the projected generation of sodium-bearing waste through 2005 is 720,000 gal. An aggressive waste minimization program has been implemented at INTEC with the goal to reduce this waste generation by at least 35%.

G.2.3 Calcination

Calcination of radioactive waste began in December 1963 at the Waste Calcining Facility, which operated until March 1981. The New Waste Calcining Facility started operation in September 1982 and is still operational. Calcination converts liquid radioactive waste to a solid using a high-temperature (about 900°F) drying process. The solid produced, called calcine, is dry, with the consistency of granulated laundry detergent. Calcination is done because the calcined waste occupies approximately seven times less volume, is more chemically stable, and is safer to store than the liquid waste. Thus, the approximately 1 Mgal of calcine produced at the site represents approximately 7 Mgal of liquid waste calcined since 1963.

To turn the liquid waste into calcine, waste from reprocessing activities is combined with chemical additives to minimize corrosion and produce calcine with the desired physical and chemical characteristics. Then, the mixture is sprayed into a heated fluidized bed of granular solids. (A fluidized bed uses a cushion of hot gas blown through a container to float a powered material as a means of drying.) This evaporates water, nitric acid, and other volatile species and chemically transforms the waste into a dry form consisting primarily of metallic oxides. The calcine is removed from the calciner vessel and pneumatically transported to air-cooled storage bins. The main constituents in the calcined waste by weight percent for zirconium-clad fuel reprocessing waste are calcium fluoride (~54%), zirconium oxide (~24%), aluminum oxide (~15%), calcium oxide (~3%), and boron oxide (~3%) with less than 1 weight percent fission product oxides. The main constituents in the calcined waste by weight percent for aluminum-clad fuel reprocessing waste are aluminum oxide (~94%), sodium oxide (~3%), and boron oxide (~2%) with less than 1 weight percent fission product oxides (Childs et al. 1982, p. 57). The radioactivity in calcine is primarily from cesium-137, strontium-90, and their decay products. Sodium-bearing waste cannot be readily converted to calcine because it has a high sodium and potassium content. During the calcination process, the sodium and potassium form compounds that melt and agglomerate at calcination and bin storage temperatures. Calcination of sodium-bearing waste is achieved by blending with other wastes low in sodium and potassium content or by blending with nonradioactive additives.

G.2.4 Storage Tanks and Calcine Bin Sets at INEEL

Approximately 1.4 Mgal of radioactive liquid waste containing 520,000 Ci of radioactivity are stored as acidic solutions in INTEC's 11 tanks. The amount of waste is not spread evenly among the 11 tanks. Some tanks are close to capacity while others are not. One of the tanks is empty and has been declared a spare tank. The tanks are similar in design, constructed of stainless steel, and contained in underground concrete vaults. Each tank has four to five access risers. Steam jets are used to transport waste from tanks into the process system.

Eight of the 11 tanks can be cooled using cooling coils located along the tank floors and walls. These cooled tanks were used to contain the wastes and fission products (e.g., cesium-137 and strontium-90) from the thermally hottest first- and second-cycle extraction processes. Chemical raffinate from later extraction cycles and LLW evaporator concentrates were stored in the uncooled tanks. The wastes are stored in the tanks until ready for calcination.
To date, none of these tanks has leaked waste to the surrounding environment.

The 11 tanks have two different capacities and three different vault designs:

- 9 tanks have capacities of 300,000 gal
- 2 tanks have capacities of 318,000 gal (Rouse et al. 1993).

G.2.4.1 Pillar and Panel Vault Tanks

These five 300,000-gal-capacity tanks (WM-182 to WM-186) were built with a primary stainless-steel liner. These tanks are in concrete octagonal pillar and panel concrete vaults (see Figure G.4). The vaults around Tanks WM-182 to WM-184 were built in 1954 with precast concrete components including a precast T-beam roof. The vaults around Tanks WM-185 and WM-186 were modified to increase their structural strength. The tanks have 50-ft diameters, with walls 21 ft high. Except for Tanks WM-184 and WM-186, all of the tanks are equipped with cooling coils (Rouse et al. 1993, p. 6-17). The tanks were built from 1954 to 1957.

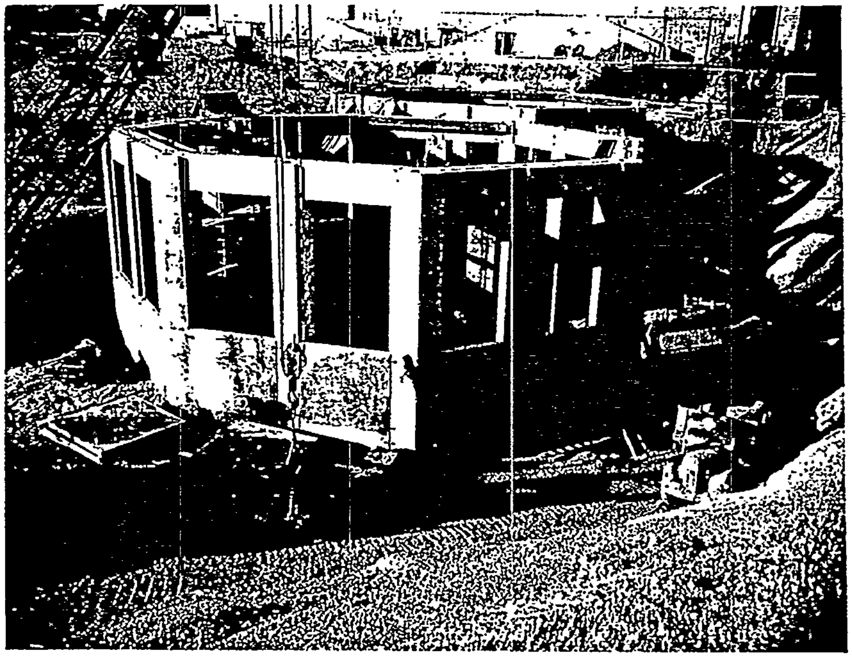

Figure G.4. Octagonal Pillar-and-Panel Vault

G.2.4.2 Rectangular Vault Tanks

These four 300,000-gal tanks (WM-187 to WM-190) were constructed with a primary stainless-steel liner. They were built within square, concrete cast-in-place vaults (see Figure G.5). Each vault contains two tanks and has a precast T-beam roof. The tanks have 50-ft diameters, with walls 21 ft high. All tanks were equipped with cooling coils. These tanks were built from 1958 to 1964 (Rouse et al. 1993, p. 6-17). Tank WM-190 is empty and is maintained as a spare.

G.2.4.3 Octagonal Concrete Vault Tanks

The two 318,000-gal tanks (WM-180 and WM-181) were built with primary stainless-steel liners and encased in cast-in-place octagonal concrete vaults (see Figure G.6). The tanks have 50-ft diameters, with walls 23 ft high. One of these tanks, WM-180, has cooling coils; the other does not. From 1951 to 1952, both tanks were built in the INTEC area. Tanks WM-180 and WM-181 entered service in 1954 and 1953, respectively, and are the oldest tanks on site (Rouse et al. 1993, p. 6-15, 6-16).

G.2.4.4 Calcine Bin Sets

Approximately 1 Mgal of calcine containing 24 MCi of radioactivity are stored in seven stainless-steel bin sets enclosed in concrete vaults with walls up to 4 ft thick. Thus, the calcine contains about 98% of the waste radioactivity at INTEC. The bin sets have a network of monitoring systems that include temperature, pressure, and radiation monitors

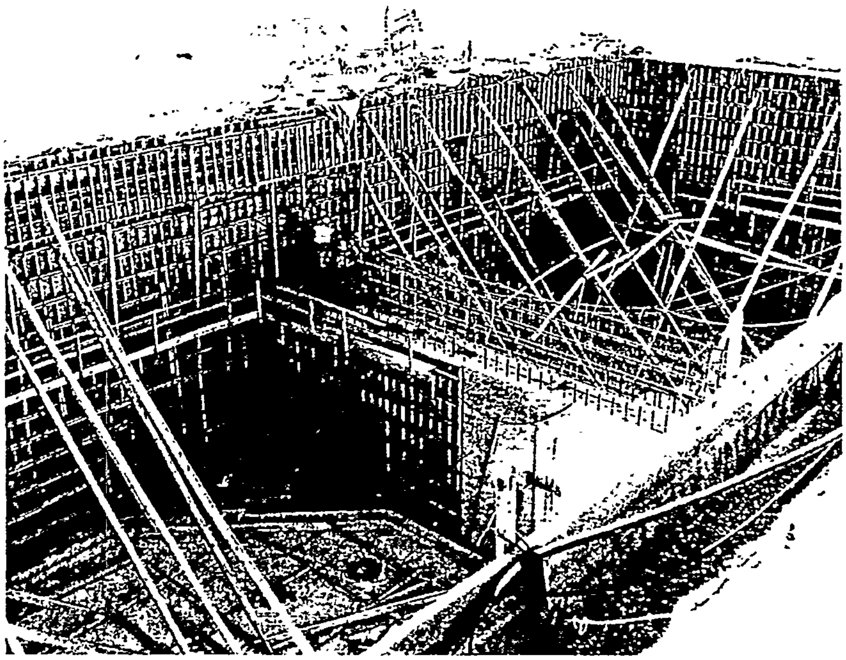

Figure G.5. Square Poured-In-Place Vault

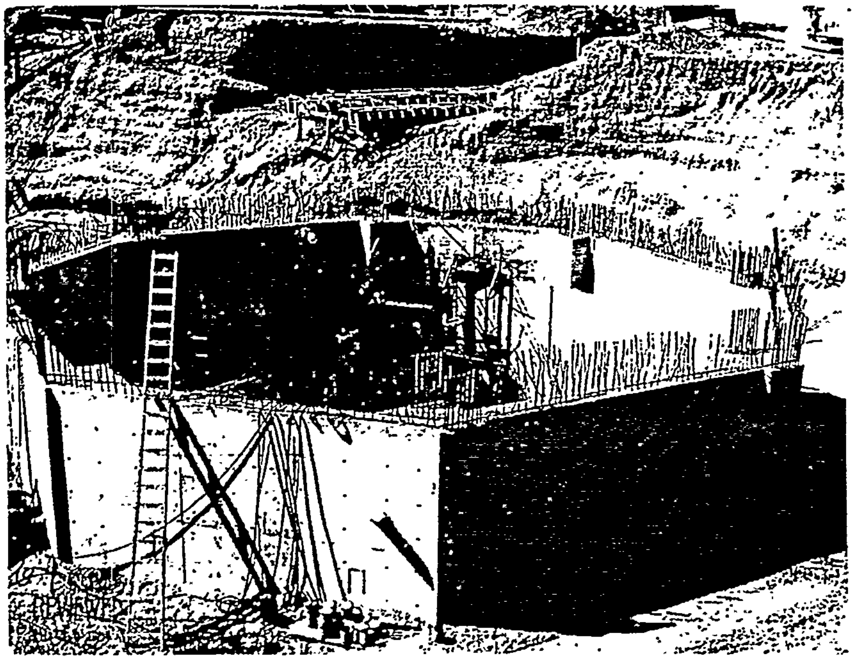

Figure G.6. Octagonal Poured-In-Place Vault

(Rouse et al. 1993, p. 6-13 - 6-15). Five of the seven storage facilities are full, the sixth is being filled, and the seventh is empty. The bins have a life expectancy of 400 to 500 years. Radiation doses of 1,000 rem/hr have been measured in the annulus space of these bins (U.S. Congress 1991, p. 45). Calcined waste is not an acceptable form for permanent disposal because of concerns that the dry waste could be easily dispersed. Therefore, the calcined waste will be converted to an acceptable final form before disposal in a geologic repository.

G.2.5 Regulatory Drivers for INEEL

Idaho's major cleanup issues for INTEC are driven by two regulations: the Notice of Non-compliance Consent Order and the Idaho Settlement Agreement. Also, the accelerating cleanup plan plays a significant role.

- Accelerating Cleanup: Paths to Closure, Idaho Operations Office. (DOE-ID 1998). The plan provides a project-by-project projection of the technical scope, cost, and schedule required to complete all 46 projects at INEEL's remaining cleanup sites.
- Notice of Noncompliance Consent Order. The Consent Order, developed by the state, requires DOE's Idaho Operations Office to cease use of the five pillar and panel vault tanks by 2009 and to cease use of the remaining six tanks by 2015. An August 1998 modification to the Consent Order accelerated these dates to 2003 and 2012, respectively.
- Idaho Settlement Agreement (Public Service Co. of Colorado Batt). The Batt Settlement Agreement (formally known as the Settlement Agreement between the Governor of Idaho (Philip E. Batt), DOE, and the Navy) requires all high-level liquid waste to be calcined by June 1998, with the remaining sodium-bearing waste calcined by 2012. By 2009, a record of decision must be issued that establishes a date for completion of the calcine treatment. (Other treatment alternatives for sodium-bearing waste may be employed to meet the intent of this agreement, in accordance with the High Level Waste Environmental Impact Statement that is currently being finalized). By 2035, DOE must remove all spent fuel from the site and have all HLW road-ready for shipment and disposal at a repository.

To meet these last agreements, the following assumptions have been made. The bulk of the liquid tank waste will be retrieved and calcined, leaving liquid heels in the tanks that will be treated as part of tank closure. Calcine will then be retrieved from the bins and dissolved. After dissolution, the resulting liquid will be separated into high- and low-activity fractions. High-activity waste, containing the cesium-137, strontium-90, and transuranic elements, will be vitrified for disposal. Low-activity waste, containing the radioactive chemicals, will be grouted and disposed. Currently, no agreements or plans have been finalized to close INTEC's tanks or calcine bins.

G.2.6 Milestones for INEEL

Selected milestones in the remediation of INEEL's radioactive waste are shown in Table G.2.

Table G.2. Idaho National Engineering and Environmental Laboratory Milestones

Milestone Title	Completion Date
Commence negotiating a plan and schedule for calcined waste treatment	1999
Commence calcination of sodium-bearing radioactive liquid waste	2001
Cease use of waste tanks in pillar and panel vaults	2003
Issue record of decision for treatment of sodium-bearing waste	2009
Complete treatment of sodium-bearing waste	2012
Cease use of waste tanks contained in monolithic vaults	2012
Complete treatment of all high level radioactive waste. Ready for offsite shipment to a repository.	2035

G.3 Oak Ridge Reservation

The Oak Ridge Reservation (ORR), located 25 mi west of Knoxville, Tennessee, was the Manhattan Project's first site for the production of nuclear material (see Figure G.7). This material included small quantities of plutonium-239 and large quantities of uranium-235. The 58-m^2 area was selected in September 1942 for several reasons, including abundant electric power, adequate surface water supply from the Clinch River, inexpensive land, and distance from U.S. population centers. Facility construction began in February 1943 and operations started by November of the same year.

Three of the site's major nuclear material production facilities were the X-10 reactor, the K-25 facility, and the Y-12 facility. The X-10 reactor, the world's first graphite-moderated reactor, was capable of producing small quantities (grams) of plutonium-239. This was an air-cooled reactor built between February and November of 1943 that was to have been the prototype for reactors at the Hanford Site in Washington State — the plutonium production site for the Manhattan Project. However, Hanford's reactor design was changed to a water-cooled system. The K-25 facility, built between 1943 and 1946, used gaseous diffusion to separate uranium isotopes. This technology was based on the principle that when uranium is turned into uranium hexafluoride gas and passed through a porous barrier membrane, the heavier uranium-238 isotope moves more slowly than the lighter uranium-235 isotopes. Therefore, the two could be separated, and the uranium-235 isotopes collected and concentrated. In 1985, the K-25 facility was placed on standby and then shut down in 1987. The Y-12 facility, built in 1943, used an electromagnetic process to separate uranium isotopes by their atomic weight. Separation was accomplished using a cyclotron as a mass spectrometer to separate the desired uranium-235 isotope from the bulk of the uranium-238, which makes up naturally occurring uranium. The electromagnetic process was discontinued after World War II.

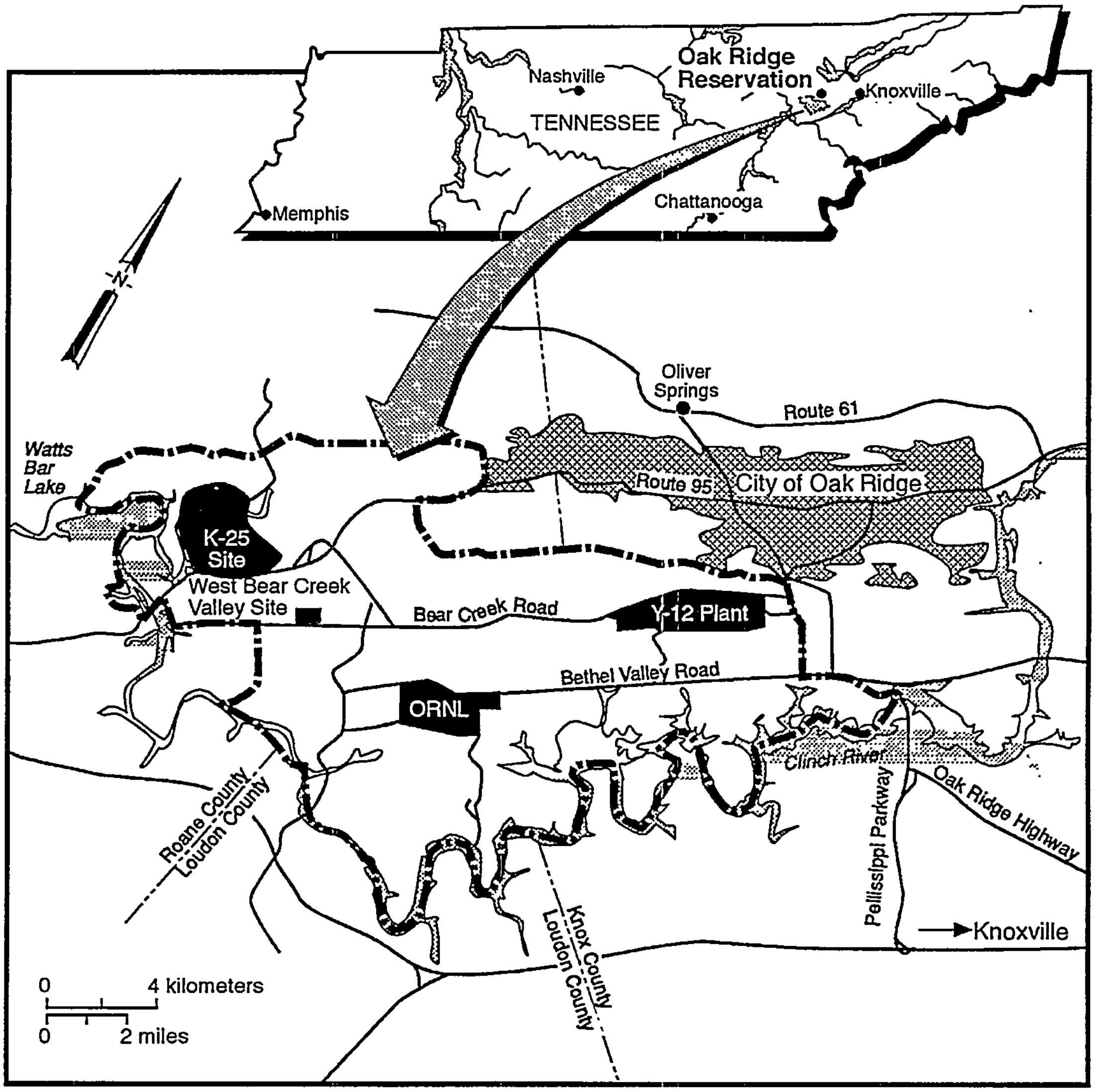

Figure G.7. Oak Ridge Reservation and Major Facilities

Over the years, X-10 site operations and research expanded. In 1948, this became known as the Oak Ridge National Laboratory (ORNL). One example of the site's expanding work was the world's first solvent extraction process (REDOX process) for chemically recovering uranium and plutonium from reprocessed spent fuel, pilot-tested at ORNL. Through 1964, the site's primary mission was to produce highly enriched uranium for nuclear weapons. From 1959 to 1969, uranium production shifted to commercial-grade, low-enrichment uranium-235 to support the nuclear power industry. The site also hosted gas centrifuge facilities used to develop and demonstrate uranium-enrichment technologies. These facilities have since been shut down.

G.3.1 Characteristics of Oak Ridge Reservation Tank Waste

Waste in ORR's 34 main tanks is classified as either low-level or transuranic waste. This waste was created from several sources, including reactor water cleanup, radiochemical process development and processing areas, facility decontamination, and laboratory operations.

Some ORR tank wastes have physical, chemical, and radiological characteristics similar to that of the HLW at other DOE sites, such as Hanford or SRS. Chemically, the waste is principally sodium nitrate as is the high-level tank waste generated from weapons production activities. However, because the U.S. definition of HLW is based on the waste's origin (waste from processing spent nuclear fuel is classified as HLW regardless of its radioactivity), the site's waste is not high level. Nonetheless, some of the transuranic waste in the sludge of some ORR tanks contain as much radioactivity as HLW at other DOE facilities (DOE 1996b).

In addition, because the ORR waste contains both radionuclides (e.g., cesium, strontium, plutonium, uranium, technetium, and ruthenium) and chemicals (e.g., lead, chromium, mercury, and some organic compounds), the waste is classified as mixed.

G.3.1.1 Legacy Waste

Approximately 436,000 gal of legacy waste containing 47,300 Ci of radioactivity (mostly cesium-137 and strontium-90) exist at ORR (DOE 1996b). About 87% (381,000 gal) of this is liquid LLW. The remaining 55,000 gal is sludge containing the bulk of the transuranic radionuclides. This legacy waste is typically 10 to 100 times less radioactive than the tank waste at other DOE sites (DOE 1996b).

Legacy waste was originally acidic. Sodium carbonate, sodium hydroxide, or lime was used to neutralize the waste to avoid rapidly corroding the carbon steel and concrete tank containers. Neutralization caused the heavy metals and transuranic isotopes to precipitate, forming layers of sludge in the bottom of many of the tanks. Most of the transuranic elements and over 80% of the fission products are in the sludge (DOE 1996b). The later addition of calcium carbonate and waste evaporation enhanced the precipitation, as well as sludge formation. Most of the legacy waste is in 16 Gunite and Associated Tanks (GAAT) and 5 Old Hydrofracture (OHF) Tanks.

G.3.1.2 Active Waste

Waste is still being generated at ORR today. This waste is called "active waste" and results from decontamination activities and ongoing research projects. Annually, about 400,000 gal of liquid waste is generated (TFA 1996a, p. A.20). Through evaporation and other processes, this is concentrated to 15,000 gal of waste containing 13,000 Ci of radioactivity (DOE 1996b). Over 99% of the radioactivity (primarily cesium-137 and strontium-90) in this waste is from a single facility called the Radiochemical Engineering Development Center. This plant recovers a variety of radioisotopes produced by irradiation of other isotopes. The active waste is stored in thirteen 50,000-gal stainless steel tanks: the eight Melton Valley Storage Tanks (MVSTs), five Bethel Valley Evaporator Service Tanks (BVESTs), and six 100,000-gal stainless steel tanks (MVCI). The MVSTs are also being used to consolidate inactive tank waste for future treatment and disposal.

G.3.2 Storage Tanks at Oak Ridge Reservation

At ORR, 40 tanks hold the bulk of the site's past and current liquid waste (DOE 1996b). Most ORR tanks were constructed in the 1940s and 1950s and had a design life of 20 to 30 years. The tanks were built using a variety of materials; some were made of carbon steel, others were made of concrete reinforced with a steel frame, and still others from stainless steel. The first two building materials are characterized by susceptibility to corrosion from prolonged exposure to chemical waste. ORR has 21 underground storage tanks that are classified as inactive and 19 large tanks classified as active. The inactive tanks are said to contain "legacy waste" from past waste generation and management practices. The 40 tanks are located in five tank farms.

G.3.2.1 Gunite and Associated Tanks

Radioactive and other hazardous chemical wastes have resulted from normal facility operations at ORR. To collect, neutralize, and store these wastes, 12 underground tanks were constructed of gunite (Figure G.8). Gunite is a mixture of cement, sand, and water sprayed through a nozzle over a steel reinforced framework (DOE 1996a, p. 1). Built between 1943 and 1951, these tanks were removed from service in the 1970s - as a result of their age and changes in onsite liquid waste system needs. These 12 tanks, along with 4 nearby stainless steel tanks, are known as the Gunite and Associated Tanks (GAAT). The largest of the gunite tanks measures 50 ft in diameter and 18 ft in height (DOE 1996b).

Four gunite and four stainless steel tanks and attached accessory equipment are in the North Tank Farm. Six gunite tanks and attached accessory equipment are in the South Tank Farm. Two separate gunite tanks also exist. Tank W-11 (a small tank reaching 8 ft in diameter with 1,500 gal capacity) and Tank TH-4 (a larger tank with a 20 ft diameter and a 17,900 gal capacity) are located in Bethel Valley, but outside the North and South Tank Farms.

None of the 16 GAAT tanks are known to have leaked waste; however, groundwater has leaked *into* the tanks. From 1981 to 1983, most of the sludge was removed from the tanks using hydraulic sluicing and transferred to the operationally active MVSTs. Prior to recent remediation activities, the 354,000 gal of supernate in the 16 tanks is low-level radioactive waste, while the 88,700 gal of sludge is transuranic waste. Approximately 18,000 Ci of radioactivity (75% in the waste sludge) exist in the tanks. Less than 1 ft of sludge remained in each tank, although a few were reported to contain several feet of sludge (Falter et al. 1995, p. 2). Five of the gunite tanks contained about 99% (mostly strontium-90) of the

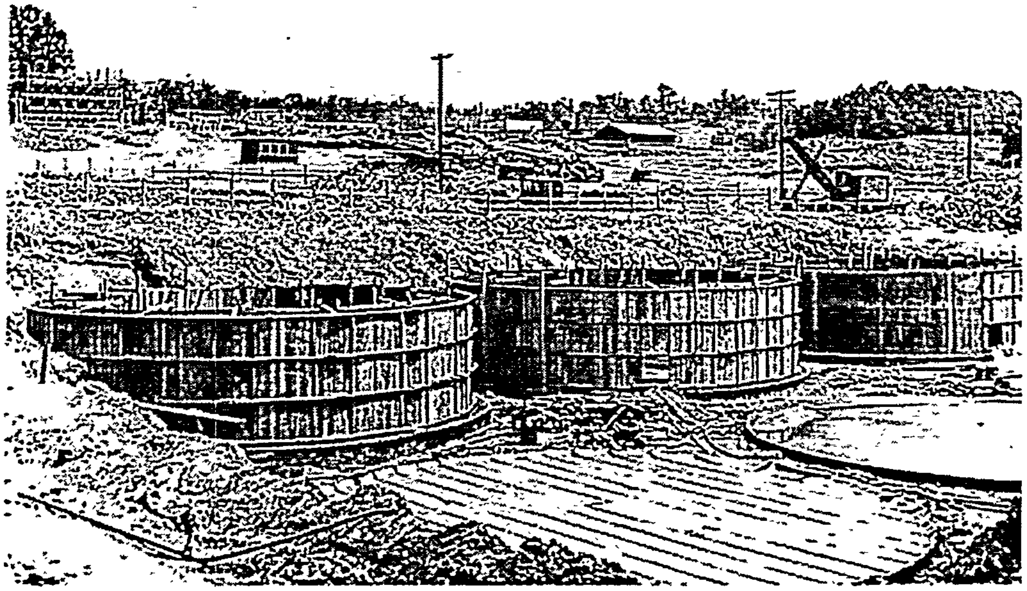

Figure G.8. Gunite Tanks Construction in 1943

radioactivity stored in all of the gunite tanks. Radiation levels were up to 100 Rad/hr at the waste surface (Falter et al. 1995, p. 1). Beginning in 1998, TFA-developed technologies were used in the MVSTs to remove the bulk of the waste from several tanks.

G.3.2.2 Old Hydrofracture Facility Tanks

The Old Hydrofracture Facility was used from 1963 to 1980 for the subsurface disposal of radioactive waste. Intermediate-level radioactive waste was blended with cement and other additives to form a grout. This grout was injected underground into a shale layer (DOE 1996b). Within the fractures in the shale, the grout hardened into thin, horizontal sheets several hundred meters wide (DOE 1994). A "New" Hydrofracture Facility was built and was used from 1980 to 1983. Hydrofracture disposal of waste ceased in 1984 and is no longer considered an acceptable disposal option in the U.S.

The tanks that held waste to be processed and disposed of at the Old Hydrofracture Facility are made of carbon steel. These five tanks vary in size from 13,000 to 25,000 gal. In 1997, these tanks contained a total of 42,900 gal of liquids and 9,800 gal of sludge that was left in the tanks when the hydrofracture operations ceased. In 1998, the bulk of the waste was removed with the Borehole Miner and sent to the MVSTs.

The tank liquids contained about 800 Ci of mostly cesium-137. The sludge contained 28,500 Ci of strontium-90, plus transuranics such as plutonium-238/239, americium-241, and uranium-233. The liquid and sludge in the OHF Tanks contained a variety of constituents; the liquid had mercury and chromium, and the sludge contained cadmium, chromium, lead, and mercury.

G.3.2.3 Melton Valley Storage Tanks

The eight MVSTs are cigar shaped, measuring 12 ft from floor to roof and 61.5 ft from end to end. The tanks are contained in stainless steel vaults equipped with sumps and liquid level detectors. Each stainless steel tank has the capacity to hold 50,000 gal; as of 1997, the tanks contained 309,000 gal of waste and 126,500 Ci of radioactivity. The waste is in the form of supernate and sludge. In the supernate, the major radioactive contaminants of concern are strontium-90, cesium-137, technetium-99, and ruthenium-106 (DOE 1996b, p. A.20). While the composition of the supernate varies, a typical chemical composition is a 4 to 5 molar sodium nitrate solution with large concentrations of soluble compounds such as potassium nitrate and sodium chloride. The sludge, which contains transuranic elements, makes up 35% of the waste volume and 80% of the radioactivity in the Melton Valley Storage Tanks. Chemically, the sludge contains insoluble compounds, such as aluminum hydroxide, calcium phosphate, and bentonite. The volume and composition of the waste in the MVSTs, which contain waste from current site activities, is changing as waste from other tanks is transferred to these tanks for final treatment.

G.3.2.4 Bethel Valley Evaporator Service Tanks

At the Bethel Valley Evaporator, five 50,000-gal stainless steel tanks were built in 1979 to hold waste before it was transferred into the evaporator. The cylindrical tanks are approximately 12 ft high and 61.5 ft long, which would cover roughly two-thirds the length of a basketball court. The tanks are filled with numerous pipes and other obstructions. As of 1997, the tanks held about 135,000 gal of waste: 96,000 gal of supernate and 39,000 gal of sludge. A total of 12,000 Ci of radioactivity existed in these five tanks. Over the years, chemical reactions in the tanks have caused solids to precipitate.

In addition to waste destined for the evaporator, the tanks contain "evaporator bottoms." Evaporator bottoms are the residual wastes from the evaporator or, stated another way, the solids that do not evaporate. For years, the bottoms were pumped back into the tanks after each evaporator campaign and have formed a layer of sludge. In 1998 and 1999, the sludge was removed from three tanks using the Fluidic Pulse Jet Mixer.

G.3.3 Regulatory Drivers for ORR

The regulatory drivers for remediating ORR tank wastes are as follows:

- Federal Facility Agreement for the Oak Ridge Reservation (DOE-OR 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. 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.

- Tennessee Department of Environment and Conservation Commissioner's Order for ORR Site Treatment Plan. This requires that Resource Conservation and Recovery Act (RCRA) land disposal restricted waste must be treated for disposal per the agreed upon schedule.
- Oak Ridge Accelerated Cleanup Plan (DOE-OR 1997). The plan accelerates cleanup of the site by 50 years. The high funding case will treat and disposition all transuranic legacy waste by 2006 (2010 in the low funding case). Privatization will be an integral part of achieving clean-up goals.

G.3.4 Milestones for ORR

Selected ORR milestones are shown in Table G.3.

Table G.3. Oak Ridge Reservation Milestones

Milestone Title	Completion Date
Complete Bethel Valley Remedial Action	2006
Complete White Oak Creek Remedial Action	2006
Complete legacy transuranic waste treatment	2006
Complete legacy mixed and low-level waste treatment	2006

G.4 Savannah River Site

Construction of the 310-m^2 Savannah River Site (SRS), in South Carolina, began in 1951. The site is located approximately 12 mi south of Aiken, South Carolina, and 13 mi southeast of Augusta, Georgia (see Figure G.9). The site borders the Savannah River and has several streams running through it. The site's primary original missions were to produce tritium and plutonium-239 for nuclear weapons, plutonium-238 to support the space program, and special medical isotopes. As a result, 36.1 metric tons of weapons-grade plutonium were produced, roughly one-third of the total 104 metric tons produced in U.S. government reactors (Usdin 1996). [The rest came from Hanford.] In 1991, SRS stopped producing nuclear materials for weapons. However, the spent nuclear fuel reprocessing facilities still operate on a low-activity basis as required to supply, for example, plutonium-238 to the National Aeronautics and Space Administration for powering deep space probes. Today, the site's primary mission is to manage and clean up the nuclear wastes that resulted from its production mission.

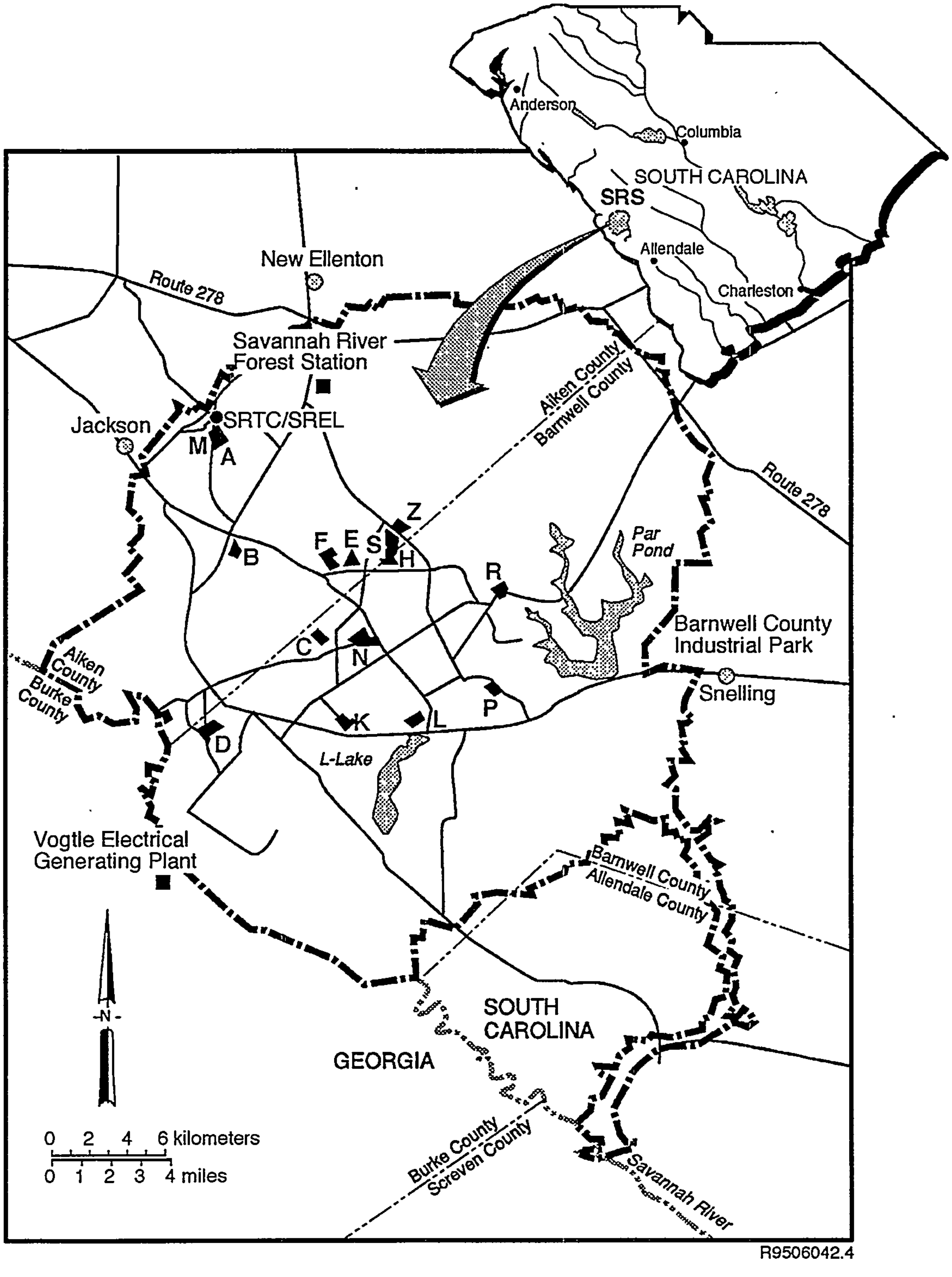

Figure G.9. Savannah River Site and Major Facilities

Because of its nuclear production work, SRS contains numerous facilities — from office buildings to nuclear reactors. Five heavy-water-moderated reactors, which produced plutonium and tritium, and a heavy-water production plant are on the site. Two reprocessing facilities were built (F Canyon and the H Canyon), along with supporting structures, to extract plutonium and uranium from irradiated nuclear fuel.

G.4.1 Characteristics of Savannah River Site Tank Waste

Soluble chemical constituents are primarily sodium salts such as sodium nitrate (49 wt%), sodium nitrite (12 wt%), sodium hydroxide (13 wt%), sodium-aluminum tetrahydroxide (11 wt%), sodium sulfate (6 wt%), and sodium carbonate (5 wt%). The chemical composition of the insoluble sludges are primarily aluminum oxide (33 wt%), iron oxide (30 wt%), silicon oxide (6 wt%), sodium nitrate/nitrite salts (6 wt%), and zeolite (4 wt%) (WSRC 1995).

About 10% (3.5 Mgal) of the tank waste volume is sludge. The rest is supernate (49% or 16.5 Mgal) and saltcake (41% or 14 Mgal). All of the sludge and about 27% of the salt and supernate will go to the Defense Waste Processing Facility where it will be converted to glass. The remainder of the waste will go to the Effluent Treatment Facility for treatment and release into the environment, or to the Saltstone Facility for conversion into grout. A discussion of the major facilities at SRS is helpful in understanding the characteristics of the wastes.

G.4.2 Waste Generation at SRS

The F and H reprocessing plants started operation in 1954 and 1955, respectively. They have not been officially shut down, [as have the five Hanford reprocessing plants]. Both reprocessing plants used the PUREX process and variations of that process to remove fission products from aluminum-clad spent fuel. The F Canyon reprocessed natural uranium (99.3% by weight uranium-238 and 0.7% uranium-235) while the H Canyon reprocessed more enriched uranium (higher uranium-235 content). Uranyl nitrate and two forms of plutonium nitrate (uranium and plutonium in nitric acid solutions) left each canyon. Further processing was required to convert the plutonium nitrate into plutonium metal. Four evaporators (two in the F Area and two in the H Area located near the respective tank farms) were used to evaporate liquids from the tank waste into a chemically concentrated slurry. After evaporation, the slurry was returned to the tanks. In 1997, two evaporators were in operation (one each in the F and H areas). Each evaporator processes between 3 and 3.75 Mgal of supernate per year. The Replacement HLW Evaporator has not yet been commissioned; operations are not expected to begin until Spring 2000. This new evaporator is expected to process about 9.7 Mgal of supernate per year. Some 82 Mgal of tank waste have been generated at SRS since the 1950s. Evaporation has reduced this volume by 60% - to about 34 Mgal.

Beginning in 1955 and 1957, tritium, a form of hydrogen gas, was separated and processed in the site's F and H areas, respectively. Tritium is released into the center of a nuclear weapon's plutonium core just before detonation. It supplies a pulse of extra neutrons for boosting the weapon's explosive power. The result is a thermonuclear explosion. Essentially all the tritium in the U.S. military arsenal was produced at SRS, which produced an estimated 500 lbs of tritium (International Physicians 1995, p. 249).

Tritium in the nation's weapon stockpile must be replenished continually because it has a half-life of only 12.3 years. In the past, irradiated lithium-aluminum targets were processed to separate tritium from other materials; this tritium was then purified. Today, tritium is recycled from existing weapons. All DOE tritium recycling work is conducted at SRS.

G.4.2.1 Defense Waste Processing Facility

The Defense Waste Processing Facility (DWPF) contains the vitrification processing equipment for converting highly radioactive sludge and salt solutions into glass (see Figure G.10). These waste materials are mixed with sand-like borosilicate glass (called frit) and sent to the plant's 65-ton steel and ceramic melter. Following 13 years (1983-1996) of construction and testing, the DWPF began processing HLW in March 1996.

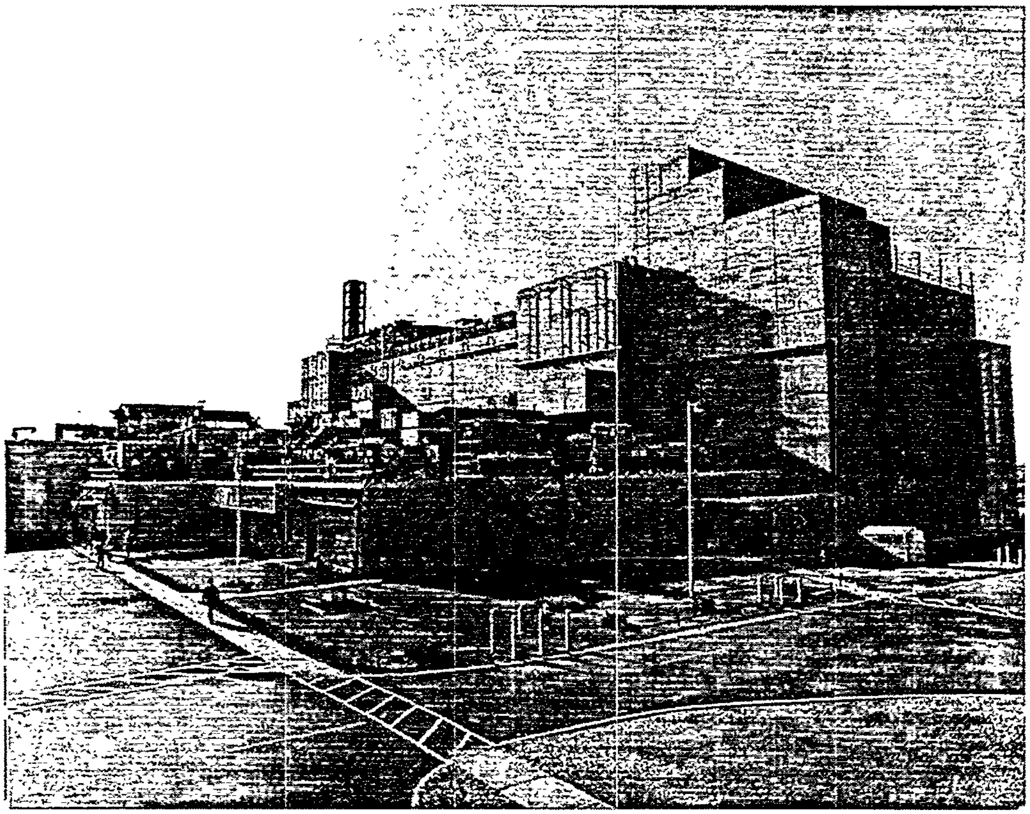

Figure G.10. Defense Waste Processing Facility

In the melter, electricity is used to heat the waste and frit mixture to 2100°F. At this point, the mixture is molten. The molten mixture is poured in a pencil-thin stream into a stainless steel canister to cool and harden. It takes about 20 hours to fill one canister. Each canister is 2 ft wide by 10 ft long and weighs about 2.5 ton when full. The exterior of each canister is blasted with frit to remove any contamination, then welded shut. The canister is then taken to a storage facility and lowered into an underground concrete vault. [As of September 1999, 710 canisters of radioactive glass have been produced.]

It will take approximately 25 years (until the year 2023) to vitrify all of the HLW currently in SRS's tanks. The canisters will remain onsite until a geologic repository opens.

G.4.2.2 Saltstone Facility

The Saltstone Facility, operating since 1990, processes and disposes of the chemical salt solution (which contains low levels of contamination) coming from the pretreatment of tank waste. This salt solution is blended with cement (10%), furnace slag (54%), and flyash (45%). After these materials are mixed with water, the grout mixture (with a consistency resembling latex paint), is pumped to a large concrete vault to harden (or cure). Once hardened, it's called saltstone. Approximately 200 Mgal of solidified saltstone will be produced. All of SRS's saltstone will contain less than one-hundredth of 1% (about 20,000 Ci of mostly technetium-99) of the original tank waste radioactivity.

The soluble salts mixed with the grout are mostly sodium nitrate. These salts make up about 93% of the 34 Mgal of HLW stored at SRS. Tank waste pretreatment separates soluble salts from the insoluble sludge to create 100-120 Mgal of salt solution. Cesium and strontium are then further removed from the salt solution using one of two proposed processes. Sludge and the additionally extracted radionuclides are sent to the DWPF for vitrification.

Plans are in progress to build 15 vaults, each covering about 2.7 acres. Fourteen vaults are designed with 12 cells inside, and one is designed with six cells. Each cell is 24 ft deep, 100 ft long, and 100 ft wide. After filling, each vault will be capped with concrete, overlaid by an engineered barrier of earth, clay, and a commercially available polymer roofing material. Construction of the Saltstone Facility and the first two vaults was completed in 1988 at a cost of $45,000,000 (1986 dollar value) (see Figure G.11.).

G.4.3 Storage Tanks at Savannah River Site

The 51 underground tanks at SRS (two have been "closed") contain about 34 Mgal of liquid HLW. An estimated 470 MCi of radioactivity exist in this waste. Some 99.4% of this radioactivity is from approximately even contributions of cesium-137 and strontium-90, plus their decay products.

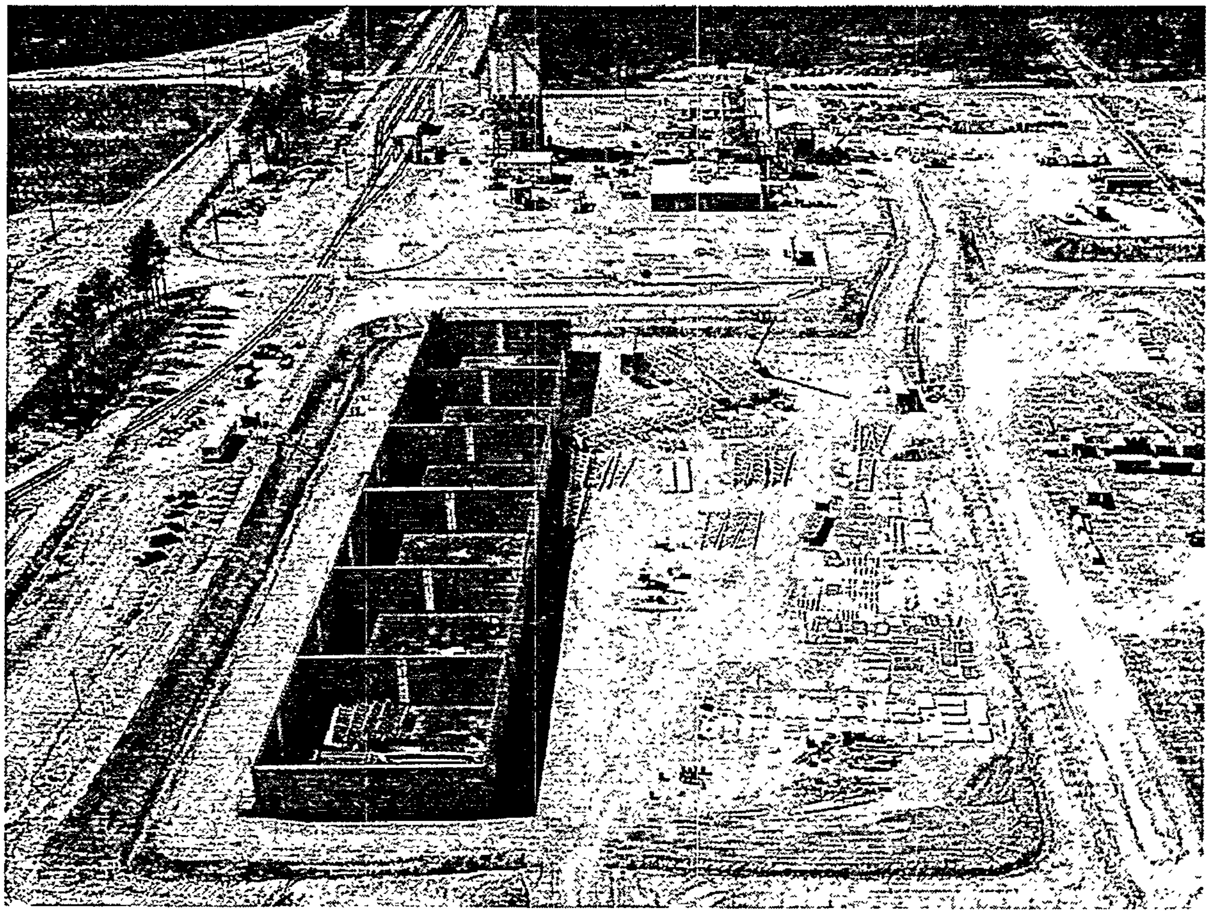

Figure G.11. Saltstone Vaults Under Construction

The tanks were built from 1951 to 1981. They are located in the F Area (22 tanks) and H Area (29 tanks) tank farms. The tanks were built with three different sizes and four designs:

- 12 have capacities of 750,000 gal
- 4 have capacities of 1.03 Mgal
- 35 have capacities of 1.3 Mgal.

Depending on location, some tanks were built below ground level and others above. The 22 tanks in the H Area were built above the natural grade and then surrounded with mounded earth. A brick encasement with an asphalt inner liner was used in the H Area because the water table sometimes rises above the tank bottoms. This was done to avoid burying the tanks within the shallow groundwater. The deeper water table in the F Area allowed burying those 29 tanks so that their tops are nearly flush with the ground surface. A waterproofing material was applied to the exterior of the F Area tank concrete shells to provide additional waterproofing to the concrete. Although tank designs are labeled Types I through IV at the site, the labeling system does not denote the chronological order in which the tanks were built.

G.4.3.1 Type I Tanks

These twelve 750,000-gal tanks were built from 1951 to 1953 in the H and F Area farms. They were placed in service in 1954. These tanks have a ½-in-thick primary steel liner that covers the top of the tank and a partially enclosed secondary outer carbon-steel liner called a "pan" that extends 5 ft up the walls. The tanks have a diameter of 75 ft and an external height of 29 ft (this includes the thickness of an outer concrete shell). Twelve concrete columns encased in carbon steel were installed within the primary liner to support the flat concrete roof. The tanks are encased in a rectangular-shaped concrete shell and buried about 9 ft underground. Each tank is equipped with 36 parallel cooling water coils suspended from the ceiling inside the primary liner (Rouse et al. 1993). Five of these tanks have leaked waste into the secondary steel liner. An estimated 27% (127 MCi) of the site's tank waste radioactivity and 12% 4 Mgal of the site's tank waste volume is contained in these 12 tanks.

G.4.3.2 Type II Tanks

These four 1.03-Mgal tanks were built in the H Area between 1955 and 1966. The first Type II tank was placed in service in 1956. These tanks have a primary steel liner that covers the top of the tank and a secondary carbon-steel liner ("pan") that extends 5 ft up the walls. The tanks have a diameter of 85 ft and an external height of about 34 ft. The primary and secondary steel liners are enclosed in concrete. A single central column is used to support a flat roof. Each tank is equipped with 44 parallel cooling water coils suspended from the roof. All four Type II tanks are known to have leaked waste. An estimated 8% (38 MCi) of the site's tank waste radioactivity is in these tanks. These tanks contain about 4% (1.4 Mgal) of the site's tank waste volume.

G.4.3.3 Type III Tanks

These 27 tanks hold the majority of the waste at SRS. The tanks have a primary steel liner that covers the top of the tank and a secondary carbon-steel liner that extends part way up the tank's outer wall. These liners are enclosed in a concrete shell and covered by a flat roof. The concrete is grooved so that circulating air can flow around the outer annulus. Any waste that leaked would move along the grooves and could be detected at the outer annulus. Tank diameters are 85 ft with an external height of 41 ft. Six of these tanks have cooling coil bundles that are suspended from the concrete roof. All 27 tanks were built in the H and F Areas from 1967 to 1982, with the first tank placed in operation in 1969 (Rouse et al. 1993) (see Figure G.12). Though none of these tanks are known to have leaked, there has been minor water leakage *into* two tanks. Most of the site's tank waste radioactivity (64% or 300 MCi) and tank waste volume (77% or 26.2 Mgal) is contained in these 27 tanks.

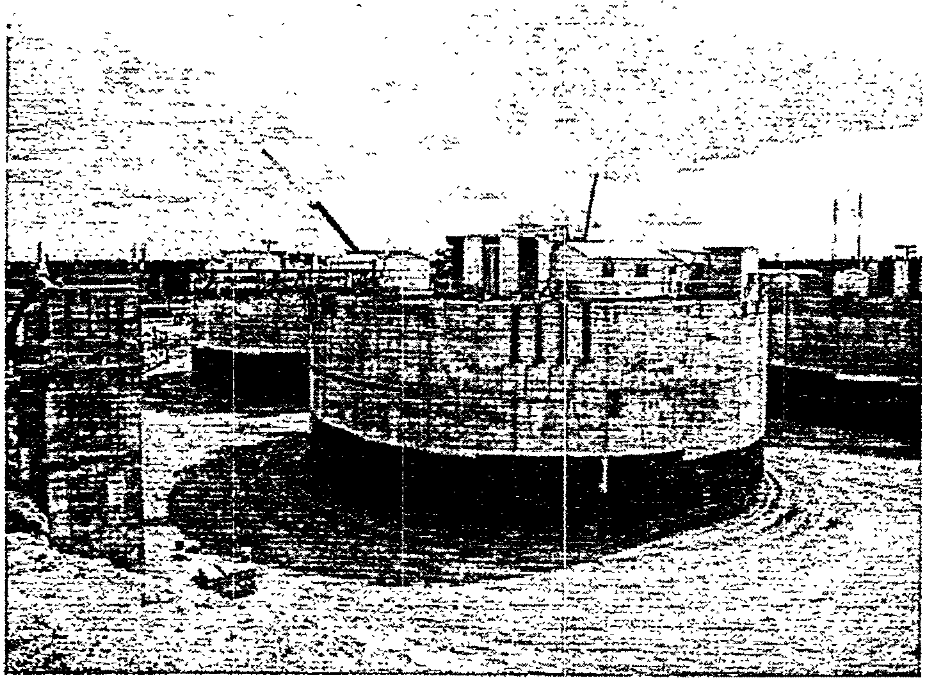

Figure G.12. Type III Tank Construction in 1980

The Type III tanks still receive small amounts of HLW from the site's limited production activities. Two types of waste are being sent: high-heat waste, which contains most of the radionuclides and must be aged in a high-heat waste tank before evaporation, and low-heat waste. After the waste is put in the Type III tanks, it separates into a bottom sludge layer and an upper layer of salts dissolved in water (supernate and saltcake). Seven of the Type III tanks are used for waste processing or feed supply (TFA 1996a, pp. A.24, A.25).

G.4.3.4 Type IV Tanks

These eight 1.3-Mgal-capacity tanks are domed with a single carbon-steel liner. The tanks have a diameter of 85 ft and the walls are 34 ft high. These tanks do not contain cooling coils as do the other three designs. Four Type IV tanks were built in the F Area in 1958, and from 1959 to 1961, four additional tanks were built in the H Area. Type IV tanks were first placed into service in 1959. Less than 1% (<5 MCi) of the site's tank waste radioactivity and 7% (2.4 Mgal) of site's tank waste volume is contained in these tanks. Monitoring records suggest that a small amount of water has leaked *into* these tanks. Waste was removed from one Type IV tank because of a leak that developed in its primary steel liner. Waste was removed from two other Type IV tanks, and the were tanks grouted and closed.

G.4.4 Regulatory Drivers for Savannah River Site

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

- Final EIS Defense Waste Processing Facility and Supplemental EIS (DOE SRS 1982; DOE-SRS 1994). The record of decision from the EIS (47 FR 23801) documents the decision to construct and operate the DWPF. Since then, DOE has prepared a supplementary EIS that addresses in-tank precipitation, saltstone processing and disposal, a late wash facility addition, and a number of other modifications to the DWPF. The record of decision (60 FR 18589) was issued in April 1995 to complete startup testing and begin operation of the DWPF.
- Savannah River Federal Facility Consent 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 DWPF.
- 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 DWPF as the preferred treatment option for treating liquid HLW.
- SRS Accelerated Cleanup Plan (DOE-SRS 1997). The plan includes removal of waste from 14 of the 24 highest risk tanks and closure of the 14 tanks (these tanks store over 111 MCi of HLW). At the end of 2006, over 37% of the HLW in tanks will be immobilized to a safe final form.

G.4.5 Milestones for Savannah River Site

Selected SRS milestones are shown in Table G.4.

Table G.4. Savannah River Site Milestones

Milestone Title	Completion Date
Startup Salt Waste Processing	2008
Start Shipping Canisters to the Federal Repository	2015
Complete Closure of 24 Old-Style Tanks	2019
Waste Removal Complete from All Tanks	2024
Sludge Processing Complete	2024
Salt Processing Complete	2024
Complete Shipping Canisters to the Federal Repository	2026
Complete High-Level Waste Management Activities	2027

G.5 West Valley Demonstration Project

The West Valley Demonstration Project (WVDP) is located on a 200-acre site 30 miles south of Buffalo, New York (see Figure G-13). The site is owned by the state of New York, managed by the DOE, and operated by West Valley Nuclear Services Co. under contract for the project.

The project is at the site of a commercial nuclear fuel reprocessing plant originally built and operated by Nuclear Fuel Services Company, Inc. (NFS). The facility was completed and first operated in 1966. In 1972, seven years after operations began, production ceased mainly because of unsuccessful efforts to expand the facility. During the operating period, NFS generated approximately 600,000 gal of liquid high-level waste. After a period of inactivity, the operating contractor decided against pursuing renewal of their operating permit. In 1980, with the passage of the West Valley Demonstration Project Act by the United States Congress, DOE was charged with the responsibility to implement a program demonstrating the feasibility of converting liquid high-level radioactive waste (HLW) into a solidified form acceptable for transportation and eventual disposal. Vitrification as a borosilcate glass was selected as the solidification method as a result of a recommendation by the National Academy of Sciences.

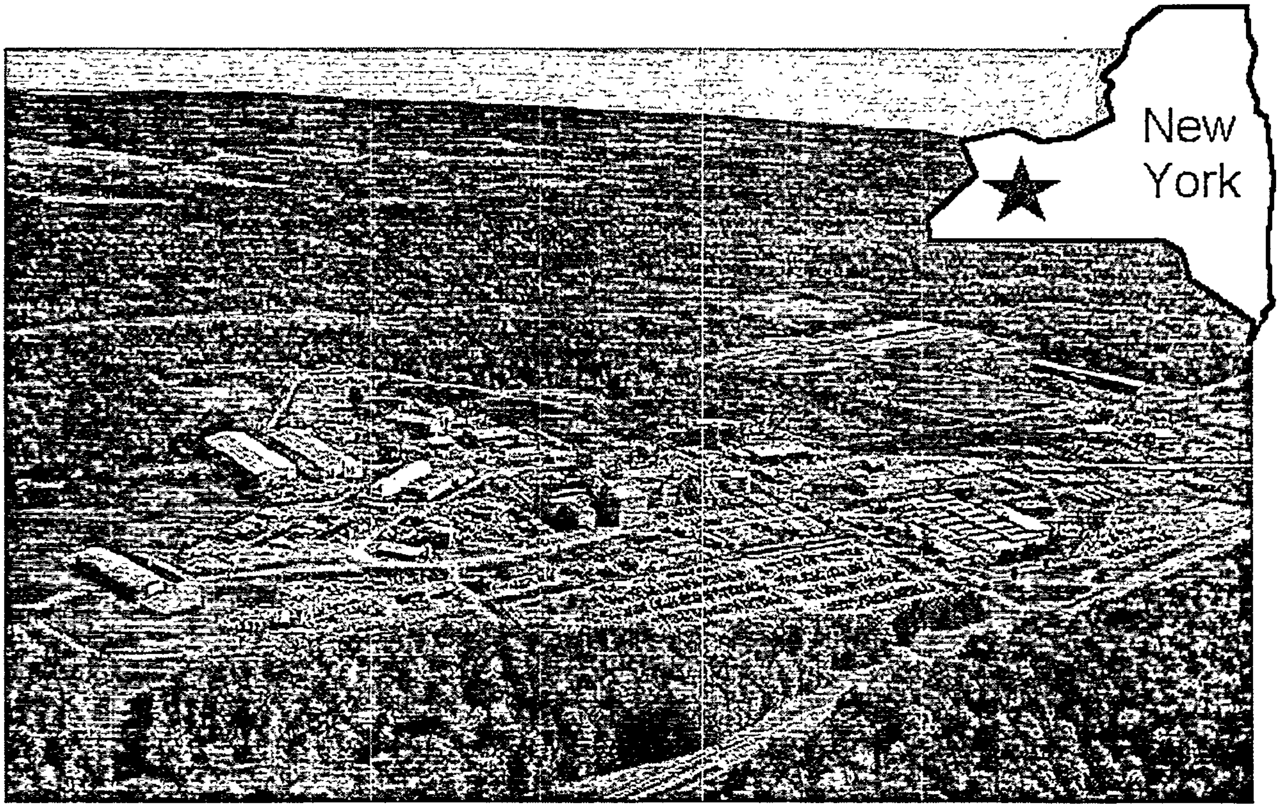

Figure G.13. Aerial View of West Valley Demonstration Project

Commencing in the early 1980s, many existing facilities were modified and new facilities constructed to meet the demonstration project mission of HLW vitrification. On July 5, 1996, WVDP filled its first canister of vitrified HLW. As of August of 1999, the project has removed approximately 95% of the waste from the tanks and produced 241 HLW canisters.

G.5.1 Characteristics of WVDP HLW

The stored HLW streams at WVDP have been in an underground tank farm facility (see section G.5.2) for an average of 30 years. This waste resulted from the reprocessing of approximately 640 tons of spent nuclear fuel. In addition to the uranium and plutonium products, the process created 2,200 cubic meters (600,000 gal) of high-level liquid plutonium uranium extraction (PUREX) waste and 30 cubic meters (8,000 gal) of thorium extraction (THOREX) waste.

Prior to being placed in storage, the PUREX waste was neutralized with sodium hydroxide. Neutralization resulted in a sludge of insoluble hydroxides in the bottom of the HLW storage tank. A liquid, supernatant layer, remained above the sludge. Strontium-90 and transuranic elements were the predominant radionuclides in the sludge, and cesium-137 was the predominant radionuclide in the supernatant. Acidic THOREX waste was stored as a single-liquid phase.

To prepare for vitrification of the waste and minimize the number of HLW canisters produced, the project used zeolite to separate cesium-137 from the supernatant. The process resulted in a greater than 99% retention of the cesium-137. It allowed the largely non-radioactive sodium and other salts detrimental to vitrification to be removed and solidified in cement. After removal of the supernatant, the remaining sludge was further processed through a series of sludge washes. The HLW holding tank was repeatedly filled with a solution of demineralized water and sodium hydroxide. This solution was also processed through zeolite to allow removal of accumulated salts, while retaining the cesium-137. As the zeolite was expended, it was placed into a spare HLW storage tank for later processing.

To complete pretreatment and consolidate the waste for vitrification, the acidic THOREX waste was combined with the remaining sludge and washed to remove salts. The majority of the zeolite was moved from storage in the spare HLW tank to the primary tank. This pretreatment process resulted in an estimated 90% reduction of canisters required to contain the remaining HLW volume destined for vitrification processing.

As of the end of FY99, the bulk of the HLW and zeolite has been removed and vitrified. WVDP HLW operations are focused on retrieving the remaining zeolite and small amounts of sludge.

G.5.2 Storage Tanks at WVDP

The original fuel reprocessing plant also included four underground storage tanks. Tanks 8D-1 and 8D-2 are single shell carbon steel tanks, each having a capacity of about 740,000 gal. Each tank is contained in a concrete vault with a pan (see Figure G.14). Tank 8D-2 was used to store waste while Tank 8D-1 was a spare. Tanks 8D-3 and 8D-4 are single shell, stainless steel, 13,500-gal tanks used to contain wastes from the THOREX process. Tank 8D-4 was the primary tank, and Tank 8D-3 was the spare. A concrete containment vault, buried 8 feet underground, acts as secondary containment for the second set of tanks. Prior to vitrification, the PUREX waste and the majority of the THOREX waste and zeolite media used in pretreatment were consolidated in Tank 8D-2.

G.5.3 Remediation and Closure Costs

Phase I of the site remediation involved the vitrification of HLW, i.e., the transformation of liquid HLW into a solidified form. This was accomplished using a slurry-fed ceramic melter. The vitrified HLW product is being stored on-site until a federal repository or alternative interim storage becomes available. Phase II remediation will incorporate decontaminating and decommissioning of facilities, tank farm disposition and transportation of vitrified and other project waste to a permanent storage location.

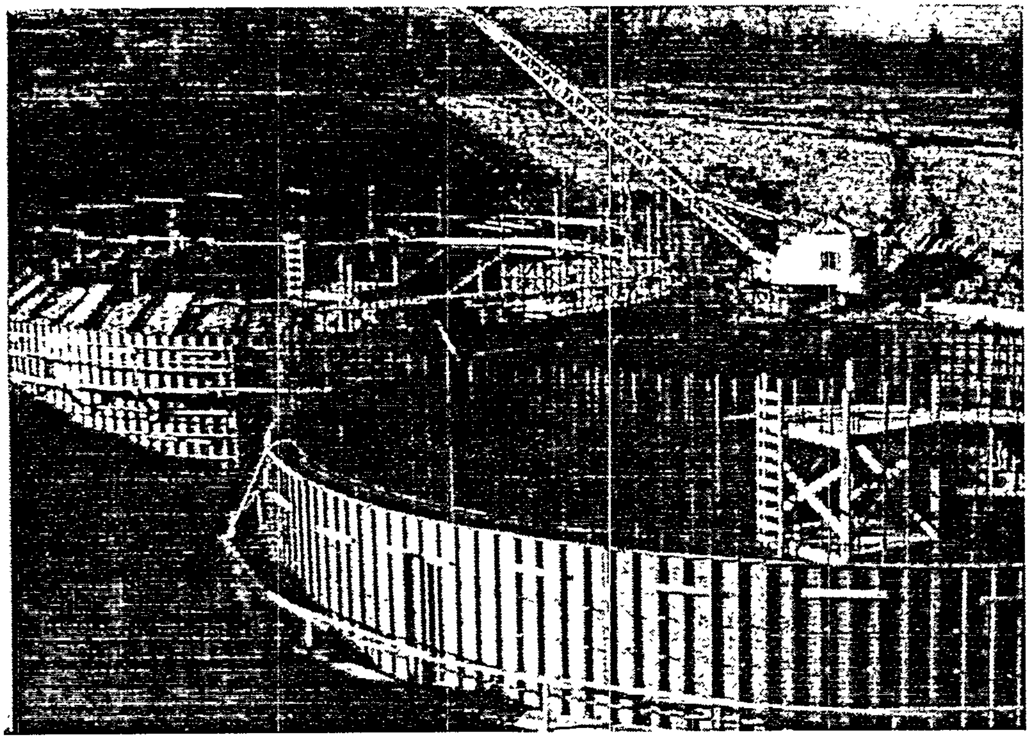

Figure G.14. Primary Carbon-Steel Tank Construction in Early 1960s

When the WVDP is completed, the DOE will transfer custody of the site back to the State of New York. Several alternatives for disposition of project facilities are being discussed including: 1) removal of all structures and off-site disposal of all wastes, 2) on-site storage of some wastes indefinitely, and 3) disassembly and entombing of process buildings and backfilling of the HLW tank farm with low density concrete (grout).

The total Phase I system cost for WVDP was estimated to be $1.394 billion. In June 1998, the project completed Phase I ahead of schedule and under budget. The Phase II costs will be based upon the pending record of decision of the EIS. The distribution costs by waste management activity are provided in Table G.5.

G.5.4 Regulatory Drivers for WVDP

- West Valley Demonstration Project Act of 1980 (PL 96-368) – This Act charges DOE with the cleanup of the HLW tanks and other contaminated facilities at the WVDP. Additionally, the Act requires that DOE develop containers suitable for permanent disposal of the solidified HLW in an appropriate federal repository.

- 1980 Cooperative agreement between DOE and NYSERDA, which defines their respective responsibilities and establishes the conditions under which DOE may use certain facilities at the Western New York Nuclear Services Center. The agreement also establishes cost sharing and other contractual conditions.

- 1991 Supplemental agreement between DOE and NYSERDA, which commits DOE and NYSERDA to jointly prepare an Environmental Impact Statement (EIS) for WVDP completion and site closure, eliminating duplication of effort and thereby furthering progress on cleanup of the tanks and site.

- Stipulation of Compromise Settlement between DOE and the Coalition on West Valley Nuclear Waste, 1986. The result of this lawsuit says that waste cannot be removed from the site until the EIS (noted above) is completed.

Table G.5. West Valley Demonstration Project System Costs

Needs Breakdown Structure	Waste Management Activity	Estimated Cost ($M)
Management Tank Wastes	Site Operations/Infrastructure	$424
Process Waste	HLW Solidification	616
	Decontamination and decommissioning	26
	Project support	296
	Low level waste handling	246
System Closure	TBD	TBD
Total (DOE & NY State) through 3rd QTR of FY99		$1,608

- Completion of the EIS and issuance of a Record of Decision (ROD) for completion of the West Valley Demonstration Project by the US Department of Energy and closure of the Western New York Nuclear Service Center. The Draft EIS was made available to the public in March 1996. The EIS identifies and describes cleanup and closure alternatives for the site. Final cleanup and closure alternatives will be selected in the ROD for this EIS.

G.5.5 Milestones for WVDP

Selected West Valley Demonstration Project milestones are shown in Table G.6.

Table G.6. West Valley Demonstration Project Major Milestones

Milestone Title	Completion Date
Complete pretreatment operations	1995
Begin radioactive operation of waste vitrification facility	1996
Complete Phase I waste vitrification activities	1998
Waste tank heel removal complete	TBD
Glass shipment	TBD
Project closure	TBD

Source: Personal communication with WVDP Site Representative on March 5, 1996
*TBD activities after ROD for EIS.

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Appendix H – Glossary

A – B

ablation	removal by cutting, abrading, or evaporating. Laser ablation refers to the use of a pulse laser beam to remove a very small amount from a tank waste sample.
alkaline	having a pH greater than seven. Bleach has a pH of about 12.5, ammonia has a pH of about 11.5. Tank waste generally falls into the pH range of 9-14, with the top of the range being an extremely basic solution.
alpha particle	a particle consisting of two neutrons and two protons, given off by the decay of many elements, including uranium and plutonium. Alpha particles cannot penetrate a piece of paper, so they are very easy to shield against. However, alpha-emitting isotopes inside the body can be very damaging.
annulus	the space that separates the two carbon steel walls of a double-shelled tank. The annulus provides a margin of safety in the case of leaks from the primary containment, because the leak can be detected and waste removed before it might escape and enter the underlying soil.
aquifer	a permeable geologic formation that can hold and transmit large quantities of groundwater.
background radiation	radiation from natural radioactive materials always present in the environment, including radiation from the sun and outer space, and radioactive elements in the upper atmosphere, the ground, building materials, and the human body. Natural sources in the United States generate an average of about 300 millirem per year.
baseline	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 formally established, baselines are subject to change control procedures.
beta particle	a particle emitted in the radioactive decay of many radionuclides. A beta particle is identical to an electron. It has a short range in air and a low ability to penetrate other materials.

Bethel Valley Evaporator Service Tanks	these five tanks at the Oak Ridge Reservation have 50,000-gallon capacities and a similar configuration to the Melton Valley Storage Tanks. The tanks contain 60,000 gallons of supernate with 4,000 curies and 20,000 gallons of sludge with 8,000 curies. This is newly generated waste.

C – D

calcination	this process converts liquid, high-level radioactive waste to a solid using a drying process with a high temperature fluidized bed. Calcination achieves a 7-to-1 volume reduction and can be stored up to 500 years. At Idaho National Engineering and Environmental Laboratory, 1 million gallons of calcine containing 50 million curies is currently stored in 7 vaults.
calcine	a dry, granular waste form with the consistency of laundry detergent. Calcine is created by the process of calcination and stored in vaults at Idaho National Engineering and Environmental Laboratory, near Idaho Falls, Idaho.
canister	the outermost container, generally made of stainless steel or an inert alloy, into which vitrified high-level waste or spent fuel rods are placed.
Class A Low-Level Waste	defined by the U.S. Nuclear Regulatory Commission. To be categorized as Class A Low-Level Waste, the final waste form must contain less than 10 nanocuries per gram of alpha-emitting transuranic elements with half-lives greater than 5 years, less than 0.04 curies per cubic meter of strontium-90, and less than 1.0 curie per cubic meter of cesium-137.
closure	long-term stabilization of underground storage tanks
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	(often called the Superfund); the 1980 federal statute that provides for the compensation, liability, cleanup, and emergency response for hazardous substances released into the environment and for the cleanup of inactive waste disposal sites. CERCLA was amended in 1986 and applied to waste sites owned by the federal government.
contamination	radioactive or hazardous chemical materials where they are unwanted or in a concentration that threatens human or environmental health.

corrosion coupon	in reference to a waste storage tank: a piece of metal, of like material to that of a tank, that is inserted into the tank waste and left there for a period of time. Once pulled from the tank it is evaluated for corrosion. The presumption is that the tank material (walls, dome, etc.) will perform just as the "coupon" does.
Corporate Review Budget (CRB)	the budget developed for the fiscal year +2. For example in April 2000, the TFA will develop its budget for FY2002. CRB is synonymous with IRB (Internal Review Budget).
critical mass	the mass of radioactive material that is enough to begin a nuclear chain reaction. For plutonium-239 and uranium-235 metals, this is about 25 and 110 pounds, respectively. Under certain conditions, as little as 1 pound of plutonium can form a critical mass.
crosscutting program	a program that manages common technology needs across the sites.
curie	a basic unit used to describe the intensity (strength) of radioactivity in a material. A curie is a measure of the rate at which a radioactive material gives off particles and disintegrates. It is also the amount of radioactivity in 1 gram of the isotope radium-226. One curie gives off 37 billion disintegrations per second. A typical home smoke detector contains about 1 millionth of a curie of radioactivity.
cyclotron	a circular particle accelerator in which charged subatomic particles generated at a central source are accelerated spirally outward in a plane perpendicular to a fixed magnetic field by an alternating electric field.
defense waste	radioactive waste resulting from weapons research and development, the operation of naval reactors, the production of weapons material such as plutonium, the processing of defense spent fuel, and the decommissioning of nuclear-powered ships and submarines.
Defense Waste Processing Facility	a high-level waste vitrification plant built at the Savannah River Site. The plant began vitrifying waste in 1996. At this plant, the waste is vitrified and then poured into stainless steel canisters. These 3,700-pound filled canisters are currently being stored at the Site, but eventually will be transported to a geologic repository. As of October 1996, the plant had been running for 6 to 8 months and produced 72 canisters of high-level waste glass.

disposal	removal of contamination or contaminated material from the human environment, although with provisions for monitoring, control, and maintenance.
dose	a quantity of radiation or energy absorbed; measured in rads or rem.
double-shell tank	a reinforced concrete underground vessel with two inner carbon steel liners. Instruments are placed in the space between the two liners (called the annulus) to detect liquid leaks from the inner liner.
E – G	
effective dose equivalent	an estimate of the total risk of potential health effects from radiation exposure.
effluent	a discharge of liquid waste, as from a factory or nuclear plant.
exposure	being present in an energy field such as sunlight or other external radiation; or touching or ingesting a hazardous agent.
feed	the waste stream that enters a vitrification plant and is combined with glass formers to produce an immobilized waste product.
fiscal year	refers to the Department of Energy's fiscal year, which runs from October through September. The fiscal year is named for the latest year in the period. For example, fiscal year 1999 (FY99) runs from October 1998 to September 1999.
fission	the process in which a uranium atom absorbs a neutron and then splits into two smaller atoms, releasing a relatively large amount of energy and one or two neutrons. Then, these neutrons can cause other uranium atoms to undergo fission, releasing more energy and still more neutrons. Eventually, a nuclear reaction is achieved in which only one neutron from each uranium atom that undergoes fission causes another uranium atom to fission. This is a nuclear chain reaction. Fission products are the smaller atoms produced by the splitting of the uranium atoms.
Gunite and Associated Tanks (GAAT)	located at the Oak Ridge Reservation, the 16 GAATs have capacities ranging from 1,500 to 170,000 gallons. Eight of the tanks are 170,000-gallon vertical concrete-rebar tanks built in 1943 and 1944 to support the Manhattan Project. In the early 1980s, 90 percent of the alkaline sludges were sluiced from the tanks and sent to the hydrofracture operation for disposal. Only 10 percent of the activity remains. The tanks currently hold

	sludge heels (containing 345,000 gallons of supernate with 4,000 curies) and 49,000 gallons of sludge with 14,000 curies. The supernate is considered mixed low-level waste. The sludges are considered mixed, low-level, and transuranic waste. For more information, see the Oak Ridge Reservation website.
gunite process	a concrete-rebar construction process where cement, sand, and water are mixed together and then sprayed over a steel reinforcing framework. This process, which is similar to the process used to create swimming pools, was used to build some of the tanks at the Oak Ridge Reservation in Tennessee.
H – L	
half-life	refers to the amount of time needed for a radioactive material to lose 50 percent of its radioactivity by decay. Half-lives range from less than one second to billions of years.
Hanford Site	a 560-square-mile Federal government-owned reservation located in the desert of southeastern Washington State. It was established in 1943 as part of the Manhattan Project. Its primary mission was to produce plutonium for nuclear weapons. Hanford contains nine production reactors, four chemical separation plants, and 177 underground tanks.
hazardous waste	nonradioactive waste such as metals (lead, mercury) and other compounds that pose a risk to the environment and human health.
heel	residual solid waste at the bottom of a tank
high-level waste (HLW)	waste from the reprocessing (chemical separation) of uranium and plutonium from other nondesired radioactive elements. High-level waste contains most of the radioactive elements discharged as waste to the underground tanks.
hot cell	an enclosed area and its associated equipment that provides shielding, containment, and remote handling capabilities for work involving radioactive materials, such as tank waste samples.
in situ	in place.
incidental waste	a concept originated by the Atomic Energy Commission - and subsequently used by the Nuclear Regulatory Commission and the Department of Energy - to separate high-level waste from the low-activity fraction generated during further treatment of high-level waste. Incidental waste is defined by both origin and characteristics; if the low-activity fraction of high-level waste has

	the characteristics of low-level waste (see definition of low-level waste), the low-activity fraction may be classified as incidental waste.
Idaho National Engineering and Environmental Laboratory	an approximately 890-square-mile Federal government-owned reservation located in the eastern Idaho desert. The laboratory is the site of 52 reactors. Some of these reactors were prototypes for special-purpose reactors, some were materials-test reactors, and some were designed to test safety concepts and accident conditions. Today, only the Advanced Test Reactor is currently operating.
isotopes	different forms of the same chemical element distinguished by different numbers of neutrons in the nucleus. A single element may have many isotopes; for example, there are 14 isotopes of americium. Some isotopes may be radioactive; others may not be radioactive.
leverage	to formally link budget and scope across performing organizations to gain the greatest benefit. The TFA works to leverage DOE investments in tank-related science and technology activities.
low-level waste (LLW)	a catch-all category for any radioactive waste that is not spent fuel, high-level, or containing large amounts of transuranic (e.g., plutonium) waste. It can include liquid waste or contaminated clothing, tools, and equipment. [See also, Class A Low-Level Waste]
M – O	
Manhattan Project	the U.S. Government project that produced the first nuclear weapons during World War II. The Hanford Site, the Oak Ridge Reservation, and the Los Alamos National Laboratory were created for this effort.
Melton Valley Capacity Increase Tanks	six new stainless steel tanks built in the Melton Valley area at Oak Ridge Reservation. While similar in design to the original Melton Valley Storage Tanks, these tanks have larger, 100,000-gallon capacities. These tanks went on line in December 1998.
Melton Valley Storage Tanks	eight 50,000-gallon horizontal stainless steel tanks at the Oak Ridge Reservation. The Melton Valley Tanks have a primary shell that holds the waste and a secondary shell that stops leaked waste before it can reach the environment. The tanks contain 200,000 gallons of supernate with 20,000 curies and 100,000 gallons of sludge with 100,000 curies. The source for this waste is

	residuals from gunite tanks and newly generated waste from reactors and decontamination and decommissioning operations. The supernates are classified as mixed low-level waste. The sludges are mixed transuranic waste.
mixed waste	waste that contains both radioactive and hazardous waste components.
multiyear program plan (MYPP)	a document that includes high-level descriptions of planned scope, schedule, and budget for several years. The MYPP defines the TFA technical program and provides the basis for requests for proposals. The MYPP is reviewed at least annually to determine if changes are necessary.
Oak Ridge Reservation	a 58-square-mile Federal government-owned reservation located near Knoxville, Tennessee. The site was established in 1943 to produce enriched uranium. The Tanks Focus Area is focused on four sets of tanks: inactive Gunite and Associated Tanks, inactive Old Hydrofracture Facility Tanks, active Bethel Valley Evaporator Service Tanks, and active Melton Valley Storage Tanks. Combined, the tanks contain 648,000 gallons of supernate with 31,300 curies, and 177,000 gallons of sludge with 154,500 curies.
Old Hydrofracture Tanks	five horizontal carbon steel tanks at the Oak Ridge Reservation. They have capacities ranging from 13,000 to 25,000 gallons. The tanks contain 37,000 gallons of supernate and 6,100 gallons of sludge.

P – R

paths to closure	a Department of Energy term referring to the schedule, activities, and costs for completing the government's environmental cleanup mission.
plutonium	a manmade element capable of being split by a low-energy neutron. Plutonium-239, which is used to make nuclear weapons, has a half-life of 24,000 years.
pneumatic	the use of compressed air
portfolio	a grouping of investments that maximizes returns while minimizing risk.
pretreatment	chemical or physical treatment process or a series of processes used to prepare waste for immobilization.

privatization	a contractual agreement between a governmental entity and a private company to provide goods or services for a negotiated fee using privately developed, financed, constructed, owned, operated and deactivated facilities.
rad	acronym for radiation absorbed dose; a unit that measures the amount, or dose, or radiation absorbed by any material, such as human tissue. Rad is the amount of radiation absorbed, rem is the potential damage done to a human from that absorption.
radiation	particles or energy waves emitted from an unstable element or nuclear reaction.
radioactivity	the property possessed by some isotopes of elements of emitting radiation (alpha, beta, or gamma rays) spontaneously in their decay process.
radionuclide	a radioactive atomic species or isotopes of an element.
rem	an acronym for roentgen equivalent man; a unit of radiation dose that indicates the potential for impact on human cells. "Quality factors" (such as 10 for beta particles and 20 for alpha particles) are given to the different kinds of radiation to convert rad to rem.
remediate	to correct a fault or deficiency; commonly referred to as "cleanup" when referring to the nation's nuclear waste.
reprecipitation	the separation of solids from a solution following previous (or earlier) dissolution processes.
reprocessing	the process by which fuel that has been used in a reactor (spent fuel) is separated into useful materials such as uranium and plutonium and waste products.
Resource Conservation and Recovery Act of 1976 (RCRA)	the federal law that regulates the management of hazardous waste, including the hazardous component of radioactive mixed waste, at operating facilities. With respect to the U.S. Department of Energy site cleanup, RCRA is concerned with the assessment and cleanup of waste sites and sites associated with operating facilities.
rheology	the study of the deformation and flow of matter.

riser	a pipe, varying in diameter, that connects the tank to the surface. The number of risers, their availability (some are used for equipment such as thermocouple trees), and location are key issues in sampling and retrieving waste.

S – T

saltcake	the crystalline water-soluble solids in waste tanks.
Savannah River Site	the approximately 300-square-mile Federal government-owned reservation located near Aiken, South Carolina. (DOE, 1995, Closing the Circle, pg 98) The Site's primary missions were to produce tritium and plutonium-239 for atomic weapons, plutonium-238 to support the space program, and special nuclear materials to support medical programs. In 1991,production of nuclear materials for weapons use stopped at the site. However, spent nuclear fuel reprocessing facilities are still operated to supply uranium to the National Aeronautics and Space Administration. The site contains five heavy-water-moderated reactors, a heavy-water production plant, facilities for making fuels and targets, a research laboratory, and two chemical extraction areas.
single-shell tank	an older style of underground tank that has a single carbon-steel liner surrounded by reinforced concrete. The domes of these tanks are made of concrete without an inner covering of steel.
sludge	a thick layer containing chemicals that have precipitated or settled to the bottom of a tank. Sludge can be difficult to pump.
sorbents	chemicals that act as a "sponge" to capture unwanted elements from a waste stream during pretreatment processes. Sorbents eventually lose their binding ability and must be replaced.
spent fuel	fuel that has been "burned" (irradiated) in a nuclear power plant's reactor to the point where it no longer contributes efficiently to the nuclear chain reaction. Spent fuel is thermally hot and highly radioactive.
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.
stage-gate	refers to the Department of Energy's six-step process for reviewing and evaluating the development of a technology, from basic research through deployment.

Superfund	a nickname for the Comprehensive Environmental Response, Compensation, and Liability Act of 1980; the federal statute that provides for the compensation, liability, cleanup, and emergency response for hazardous substances released into the environment and for the cleanup of inactive waste disposal sites. CERCLA was amended in 1986 and applied to waste sites owned by the federal government.
supernate	the upper layer of salts in a waste tank dissolved in water.
transuranic element	elements, such and plutonium and neptunium, that have atomic numbers (number of protons in the nucleus) greater than 92. All are radioactive.
transuranic waste	waste contaminated with alpha-emitting elements that have atomic numbers (number of protons in the nucleus) greater than 92 with half-lives greater than 20 years in concentrations of more than 1 ten-millionth of a curie per gram (0.03 ounce) of waste.
U – Z	
U.S. Nuclear Regulatory Commission	an independent federal agency established in 1974 to develop and enforce regulations regarding civilian nuclear activities, such as power plants. The NRC has developed regulations for high-level and low-level waste disposal and is responsible for licensing nuclear waste facilities, including the high-level waste repository.
users	staff and organizations located at the five waste tank sites responsible for managing the wastes.
uranium-235	the lighter of the two main isotopes of uranium. Of the uranium that is mined from the earth, 0.7 percent of it is uranium-235. It has a half-life of 714 million years and is the only naturally occurring element capable of being split by a low-energy neutron. Uranium-235 is used in the production of plutonium-239.
vadose zone	a geological zone that encompasses the soil from the ground surface to, but not including, the groundwater; often used in reference to the soil around a tank or tank farm.
vitrification	a process that combines concentrated radioactive waste (mostly cesium and strontium) and glass-forming materials. The melted glass-waste mixture is poured into metal canisters, where it hardens into logs. Vitrification plants have been built in the United Sates at West Valley, New York, and the Savannah River Site in South Carolina.

waste	in this context, unwanted materials left over from the production of nuclear materials. This type of waste has been disposed of in numerous ways, such as dumping it to the soil, into rivers, into aboveground or below ground tanks, and/or burying it in boxes or drums.
waste management	the treatment, storage, and disposal of radioactive waste, hazardous waste, mixed waste, and sanitary waste.
Watch List	a list of tanks published in Public Law 101-510, Section 3137 (also known as the Wyden Bill). The law requires DOE to treat listed tanks in such a way as to avoid any potential releases of materials to the environment.
water table	the upper surface in an aquifer where the pore spaces in the geologic formation are filled with water that moves down a hydraulic gradient.
weapons-grade uranium	uranium that contains over 90 percent uranium-235.
West Valley Demonstration Project (WVDP)	a 200-acre site located near West Valley, New York. The WVDP began operations in 1966 as a demonstration facility for reprocessing commercial spent fuel to recover uranium and plutonium. From 1966 to 1972 the facility produced 550,000 gallons of highly radioactive waste before the site operator, Nuclear Fuel Services, Inc., halted operations to evaluate the facility's expansion potential. In 1980, the WVDP Act was signed, directing the U.S. DOE to solidify and develop suitable containers for the site's high-level radioactive waste; transport the solidified waste to a federal repository; and dispose of the low-level radioactive and transuranic wastes created during project operations. West Valley Nuclear Services Co., Inc., was awarded the operations contract and has been the primary contractor ever since.

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