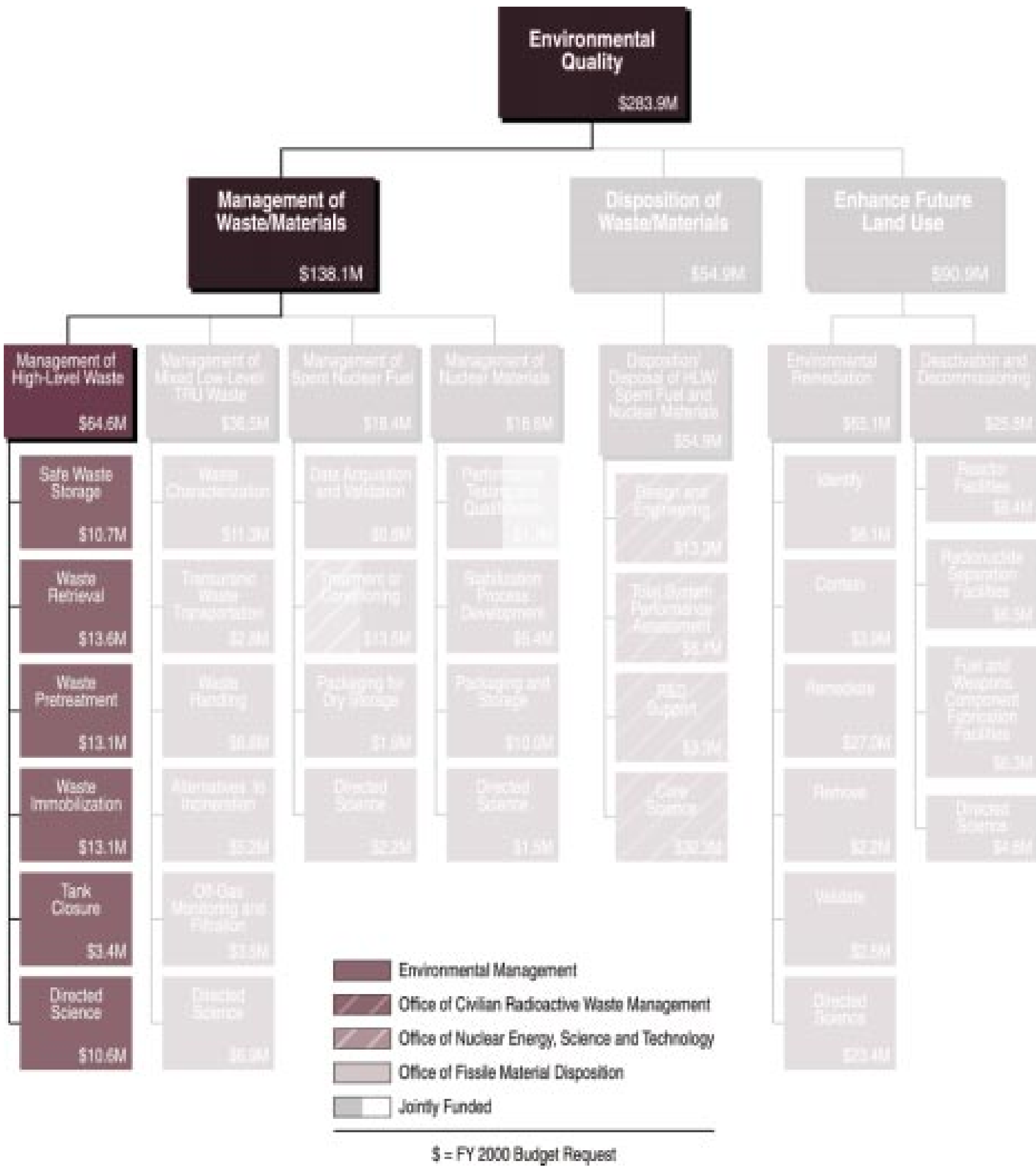
# Chapter 3
# High-Level Waste



## Chapter 3
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# Overview

### *Definition of Problem Area*

High-level waste (HLW) was generated during production of nuclear weapons and reprocessing of reactor fuels. There are 277 large radioactive waste storage tanks and more than 63 miscellaneous underground storage tanks across the DOE complex containing over 90 million gallons of radioactive waste. Most of these tanks have exceeded their design life, some have leaked, and all represent significant occupational and public risks. Current site baseline technologies are costly, pose significant programmatic and safety risks, and have technology gaps. The waste is currently stored at five main locations.

- The Savannah River Site (SRS) has 51 tanks (two closed) storing 34 million gallons of waste containing about 450 million curies (MCi) of radioactivity.
- In Washington State, Hanford has 177 tanks that store 55 million gallons of waste containing about 200 MCi of radioactivity.
- The Idaho National Engineering and Environmental Laboratory (INEEL) has 11 tanks with 2 million gallons of liquid waste containing 2 MCi of radioactivity and 1 million gallons of dried waste with 47 MCi of radioactivity stored in six bin sets.
- Oak Ridge Reservation (ORR) in Tennessee has 825,000 gallons of waste containing 220,000 Ci of radioactivity in 34 tanks. (Though not HLW, this is included in the HLW section because the waste and tank problems are similar to those faced by HLW sites.)
- West Valley in New York State is currently processing waste from their four tanks.

To protect the public and the environment, this waste must be 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. The total life-cycle cost projected for HLW cleanup is $49 billion, as illustrated in Figure 3-1.

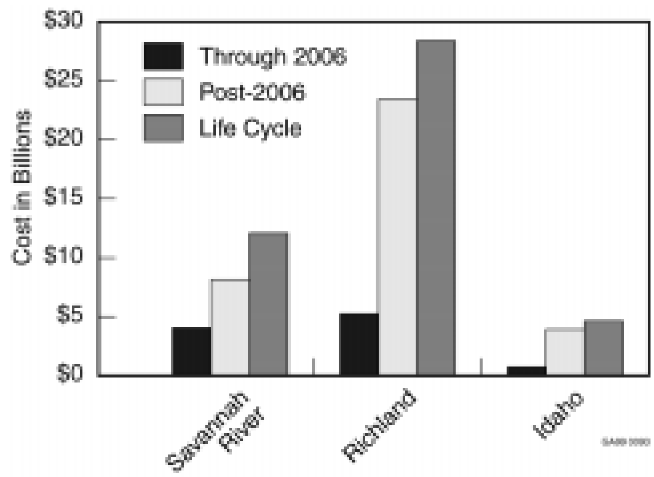


*Figure 3-1. Pre-2006, post-2006, and life cycle costs for managing high-level waste.*

***National Context/Drivers and Federal Role***

The Department continues to face a major radioactive tank waste remediation problem with over 300 underground storage tanks that have been used to process and store more than 90 million gallons of radioactive HLW and chemical mixed waste. Approximately 80 tanks are known or assumed to have leaked. 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 and the waste disposed of to minimize the risk of waste migration and/or exposure to workers, the public, and the environment. Many of the wastes within the tanks are unique, possessing characteristics that have never been encountered in the management of other industrial/radioactive wastes. These difficulties are compounded by the fact that programmatic drivers are more ambitious than baseline technologies and budgets will support. As a result science and technology investments are required to reduce the technical and programmatic risks associated with the tank remediation baselines.

HLW management is a problem unique to government. While some problems are shared with industries such as mining, oil production, and chemical, the hazards of working in a highly-radioactive environment with many materials of varying or unknown chemical and physical properties is truly unique. As other governments face similar issues, DOE actively engages other countries, notably Russia and the United Kingdom, to bring added expertise and technologies successfully used in those countries.

Generally, government-owned national laboratories perform HLW management research and development, with assistance from selected universities and private and foreign organizations. The Department is attempting to increase its use of existing private technology in the application of solutions to national HLW remediation problems at several sites. However, access to HLW is often not available to private organizations; research facilities unique to the government are required to handle these wastes. Local and national regulations also limit the transportation of HLW required for increased private sector involvement.

***Linkage to DOE Strategic Goals and Objectives***

The overall goals of the HLW management activities are to retrieve, treat, store, and dispose of HLW in a manner that is safe to humans and the environment, cost effective, and in compliance with all applicable environmental regulations.

The main goal for the HLW R&D investments is to systematically manage the development and facilitate deployment of technologies using an integrated approach to safely and efficiently achieve tank waste remediation across the DOE complex in support of the *Accelerating Cleanup: Paths to Closure* plan. This goal supports the achievement of Environmental Quality Objectives EQ1, EQ3, and EQ6. By making the HLW in the tanks disposal ready, these investments also support Objective EQ5, complementing investments related to HLW disposal described in Chapter 7. The level of impact and support of the HLW science and technology investments on the Environmental Quality strategic objectives are shown in Figure 3-2.

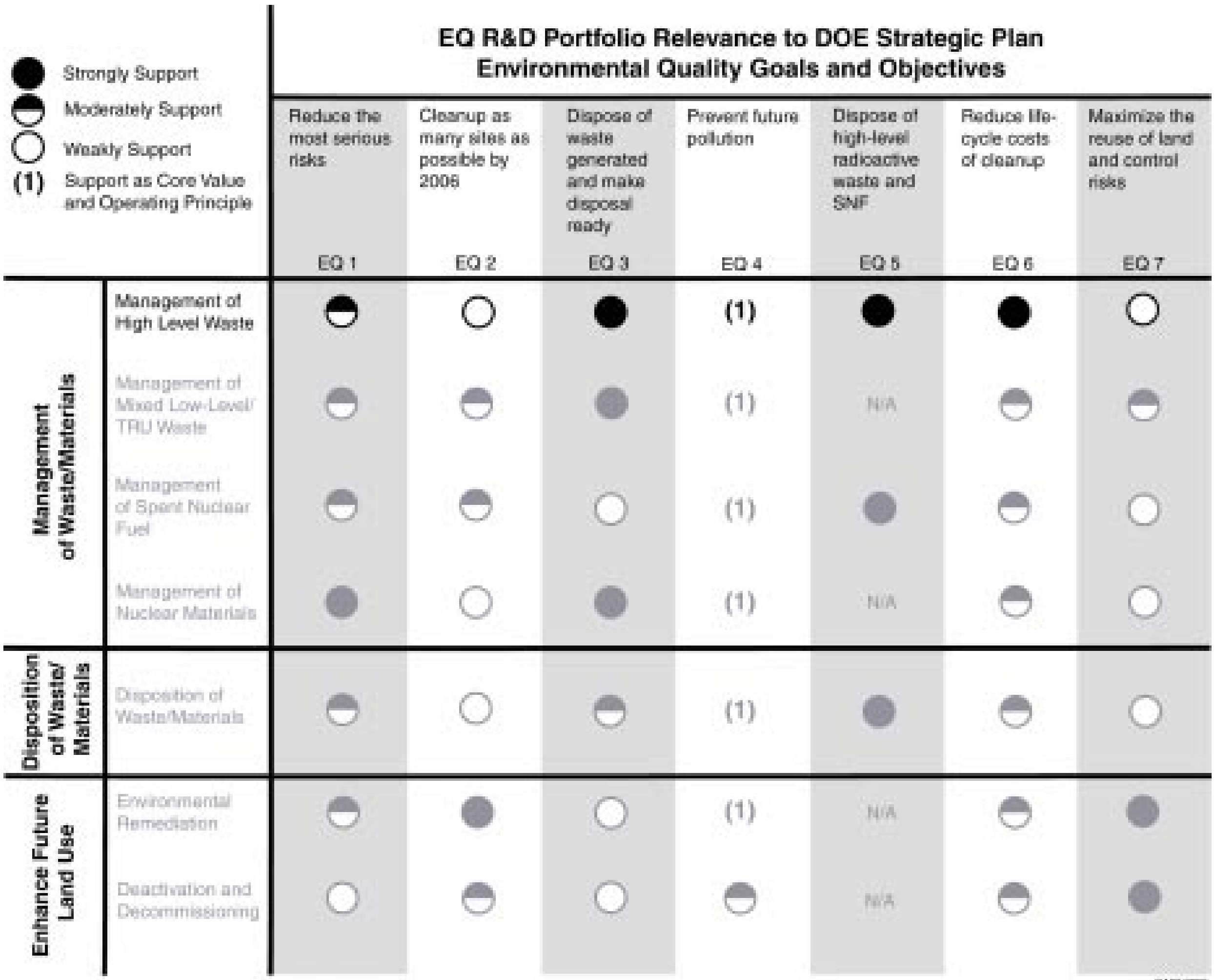


*Figure 3-2. Relevance of high-level waste R&D investments to Environmental Quality goals and objectives.*

Execution of the HLW R&D program will support complex-wide tank farm closure while minimizing life-cycle costs. Specific approaches include:

Approach #1: Increase use of DOE-funded results so that 70-90% of products are being used. The key point is the goal to *increase* the use of DOE-funded technologies. The following strategies assist in attaining this goal:

- 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 from fundamental science to technology implementation.

- Identify and build user relationships.

Approach #2: Reduce programmatic and technical risk. Essential elements of this goal are the constant pursuit of multi-site technology applications and the selection of the best technical performers available. The following strategies assist in attaining this goal:

- Maximize multi-site benefits from technology investments and expedite cleanup.
- Develop lab/industry partnerships to respond to needs and deploy technologies.
- Manage budget, budget change process, and site prioritization influences.

Approach #3: Direct up to 20% of the HLW problem area to contingency or alternative technology approaches. DOE will leverage technical expertise to anticipate problems and risk-reducing technical solutions. With the widespread support from its user community, the DOE pursues, within available funding, contingency or alternative technology approaches. The following strategies assist in attaining this goal:

- Continue to define strategic goals to guide technology investments.
- Continue to develop a basis for initiating and maintaining a forward thinking program that balances near- and long-term investments.
- Establish end-user advocacy for strategic investments.

***Problem Area Uncertainties***

The radiation levels associated with HLW waste pose extremely high worker health, safety and risk issues, requiring remote operation and maintenance of tank farm equipment and processing facilities, and storage and disposal of waste in underground facilities. Safety is the number one priority in the HLW program.

The chemical profile in HLW encompasses an extremely broad range of chemical constituents including nitrate and nitrite salts (approximately half of the total waste), hydrated metal oxides, organic complexants, phosphate precipitates, and ferrocyanides. This complexity makes the waste difficult to characterize, retrieve, process, and immobilize. In addition, the pH of HLW ranges from extremely acidic to extremely caustic. These factors, when coupled with the potential for radiolytic transformations, produce a problem that has no counterparts outside of DOE and for which there is a very limited knowledge base.

- The high costs associated with HLW management make it a frequent target for funding reductions and constant review.
- Key parameters such as agreements on a site’s end state and the identification of required cleanup levels must be negotiated with appropriate regulators and stakeholders at each site. These issues may be very complex; they often require considerable time for resolution.

- Historically, funding directed to technology development for the remediation of HLW has been insufficient to cover the technology needs expressed by the five sites. This has forced a program strategy that first responds to similar needs at several sites. Problems unique to one site have generally not enjoyed a priority high enough to receive available funding. For example, INEEL has highly acidic waste, which is unique. This has resulted in needs important to INEEL being unresolved.

- Funding shortfalls also greatly restrict the ability to fund tasks that are more strategic in nature. Available funding has not been sufficient to respond to all the priority technology development needs, which are more immediate in nature, across the five sites. Beyond those immediate needs exists more general, investigative work that does not qualify as directed science. Solutions to these strategic needs also remain unresolved.

- The uncertainty inherent in research and development activities can lead to failures or setbacks. In-tank Precipitation was thought to be a viable waste treatment option at SRS. After considerable effort, it became apparent another alternative was required. However, without this considerable scientific and engineering effort, the true viability of In-tank Precipitation could not have been determined.

***R&D Investment Trends and Rationale***

To address the HLW problem, DOE investments span the full range of technical endeavor, from basic to applied research through technology development, deployment, and technical assistance. Basic research answers fundamental questions of waste behavior (both in-tank and in the environment), while technologies developed through prior DOE investments are currently being used to characterize, retrieve, treat, and immobilize waste safely. Current HLW investments are shown in Figure 3-3.

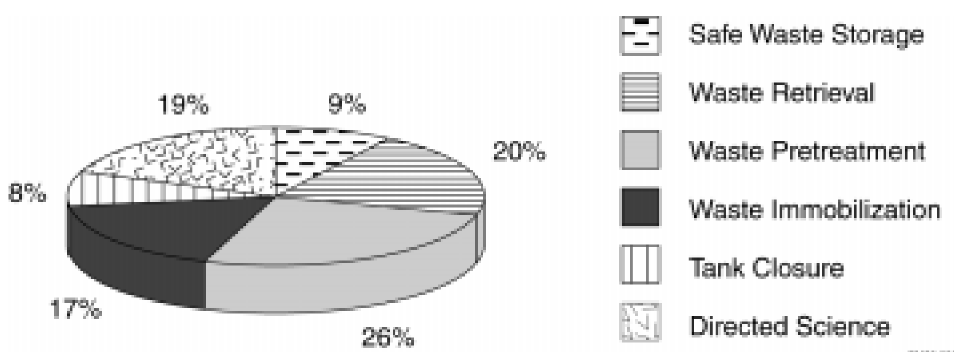


*Figure 3-3. Cumulative investment in high-level waste areas over 3 years (FY 1998–FY 2000).*

HLW research and development efforts fall into the following five major areas:

**Safe Waste Storage.** DOE's aging HLW tanks must be monitored to assure continued safe waste storage. The tanks vary in age, composition, size, shape, construction, and the environment in which they are located. The wastes inside these tanks also vary widely, creating additional challenges to maintenance of safe storage. Significant issues include tank integrity and corrosion, tank ventilation, and flammable gas generation.

**Waste Retrieval.** Tanks contain wastes ranging in consistency from soft sludges to concrete-like saltcake. Tanks also contain miscellaneous foreign objects such as Portland cement, measuring tapes, samarium balls, and in-tank hardware such as piping. Sluicing, adding large quantities of water to suspend solids, is the baseline method for sludge removal from tanks, but this process is not capable of retrieving all of the material from tanks. In addition, its use has been questioned by stakeholders due to the existing and potential leaks of hazardous and radioactive liquids from corroded and deteriorated tanks into nearby soil and groundwater. Besides dealing with aging tanks and difficult wastes, retrieval also faces the problem of the tank design itself. Retrieval tools must be able to enter the tanks, which are under an average of 10 feet of soil, through small openings called risers in the tops of the tanks.

**Waste Pretreatment.** Although the total volume of waste is considered HLW, it is neither cost-effective nor practical to treat and dispose of all the waste to meet the requirements of the Nuclear Waste Policy Act. The current baseline technology systems for waste pretreatment at DOE’s tank waste sites are ineffective and expensive. Large volumes of HLW will be generated while there is limited space for disposal. Only a small fraction of the waste is made up of radionuclides; the bulk of it is inert. Separation or pretreatment of the chemicals and radionuclides into high-activity and low-activity waste fractions will make for easier and more cost-effective treatment and disposal.

**Waste Immobilization.** Immobilization investments target solutions to problems in low-level, high-level, and secondary waste disposition. Unresolved technical issues in the development, implementation, and efficiency of grout, glass, and alternative-waste forms and processes exist. Other DOE investments address the government's interface with present and future privatized waste immobilization operations in such areas as waste form product acceptance testing and long-term immobilized waste form performance for disposal.

**Tank Closure.** Tank closure activities include the determination of closure criteria; stabilization of waste tanks for closure; the characterization, retrieval, and treatment of remaining waste residues in the form of tank heels and contaminated ancillary equipment; and the continued monitoring of waste tank sites after closure. DOE invests in research and development in all of these areas.

### *Key R&D Accomplishments*

Deployment of solutions to address site needs is the critical measure of success for DOE investments to solve HLW problems. The nature of those problems and the technical solutions and schedules vary according to the nature of the specific needs and performance objectives defined by site problem owners. Accomplishments vary from delivery of critical technology evaluation information or process data to deployment of treatment processes or systems in remediation operations. Deployment of data is accomplished when data are used by site problem owners to support: 1) key HLW storage, treatment and disposal decisions involving improvements to existing processes, 2) selection of future technologies and processes, and 3) evaluation of comparative costs and technical viability of options.

In order to monitor progress towards technical objectives and increase probability of success, key deliverables are identified that represent significant progress, accomplishments, or interim steps towards delivery of technical solutions. Progress toward delivery of solutions is measured in three areas:

- Delivery of data to support key decisions and fill gaps in technical knowledge required to define the path to solution.
- Demonstration of technologies or concepts to support selection of technology alternatives or 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.

To date, key accomplishments addressing HLW management needs include:

- Grouted and closed two HLW tanks.
- Retrieved residual waste from five tanks using remotely operated deployment systems and innovative waste dislodging and conveyance tools.
- Deployed system to isolate and remove in-tank piping to prepare for tank closure.
- Adapted and deployed power fluidic technologies proven in the United Kingdom to sample wastes from one tank and retrieve waste from three tanks.
- Deployed auger for sampling and magnetometer for measuring waste volume to improve residual waste inventory estimates for performance assessment.
- Deployed ion-exchange technology in transportable designed unit to remove cesium from waste streams reducing cost and risk for waste treatment and disposal.
- Provided critical technical expertise and technology options to assist in selecting alternatives to replace the in-tank precipitation process; two options were selected for pilot-scale technology testing and demonstration.
- Adapted and deployed mining industry technology to retrieve waste from five limited access waste tanks.
- Conducted hot-cell analysis of tank waste using advanced spectroscopy technologies.
- Deployed pulsed-air technology for tank mixing.
- Deployed in-tank corrosion monitoring technology to limit sodium inhibitor additions, ultimately reducing waste volume for disposal.

- Deployed laser-based mapping technology to investigate condition of concrete tank walls.
- Deployed mobile evaporator technology to process liquid waste reducing volume, freeing up limited tank waste storage space.
- Delivered critical data for vitrification process control enabling increased waste loading at the Defense Waste Processing Facility (DWPF).

***Key R&D Issues***

HLW management will require both near-term and long-term science and technology investments to ensure safety, reduce technical and programmatic risks, reduce costs, and enable processing and treatment to be accomplished over the next half century. Near term issues, objectives, and current program description are described in later sections. Longer-term R&D issues for each of the major areas of HLW management are described below.

**Safe Waste Storage**. Many of the radioactive storage tanks are quickly approaching or have exceeded their design life. Although tank chemistry is controlled to prevent corrosion, stress corrosion cracking has occurred in several tanks and is likely to continue. HLW management will require more than 35 more years of waste storage in many of the aging tanks before all of the waste can be retrieved and processed. In addition, processing delays and secondary waste generation are likely to require even more interim waste storage until processing can be completed. Therefore, there will be an increasing need for monitoring, prevention, and repair to maintain tank integrity and allow use of existing tanks during the life of the HLW program. The most likely problems in Safe Waste Storage will arise from corrosion-induced failure of aging waste tanks requiring costly construction of new tanks or repairs to allow processing to proceed. Mechanisms of corrosion, improved monitoring and control, and methods to inspect for, detect, and mitigate tank defects will be required.

**Waste Retrieval.** Near-term issues are focused on bulk waste mixing and retrieval to support feed delivery for processing. In addition, several sites have accelerated tank closure efforts and therefore require heel retrieval and tank cleaning technology. Longer-term issues will focus on heel retrieval from more complicated tanks, such as those with internal equipment, piping, etc. Waste from single-shell tanks with high risk of leakage will need to be retrieved with minimal water addition. To remediate tanks within the established schedule, the outyear baseline assumes that retrieval operations can be performed from multiple tanks simultaneously to achieve feed delivery and processing rates. However, the more difficult tanks and waste types are likely to be encountered in the outyears. Likely long-term problems will include failure of baseline technology to retrieve adequate volumes of tank waste to meet regulatory requirements, tank integrity failure due to aggressive retrieval operations, and inadequate retrieval capacity to maintain feed to processing facilities. Science and technology will be required to enable dry, or reduced water retrieval to avoid leakage to the vadose zone, improved heel retrieval technology with significantly reduced costs and higher rates of mobilization to meet baseline schedule and cost assumptions, and a solid understanding of tank waste chemistry to avoid unwanted upsets in retrieval and transfer due to plugged lines and other waste behavior issues.

**Waste Pretreatment.** Although solid-liquid-separation, supernate processing, and sludge processing technologies exist today that can meet near-term baseline schedules, pretreatment represents a significant portion of the HLW management costs, and a significant technical risk. Outyear processing will likely involve the more complex wastes. Secondary waste generation and waste recycle streams also contribute greatly to the volume of waste ultimately requiring treatment. Likely failures in pretreatment will involve inadequate separations due to changing waste feed chemistry, and a subsequent increase in costs of downstream waste immobilization and disposal. Advancements in separations technology will need to continue to be made to provide lower cost, more efficient alternatives that can greatly improve this portion of the tank remediation flowsheet. Reductions in the volume of waste requiring disposal as an immobilized low-activity or high-activity waste form will greatly reduce costs.

**Waste Immobilization.** Baseline immobilization processes have or are being established for each of the HLW sites. However, immobilization processing conducted to date at several sites confirms the need for longer term R&D to greatly improve operations, reduce costs, and increase throughput to allow baseline schedule and cost assumptions to be met. For example, design problems with the SRS melter pour spout has decreased throughput and increased costs of operations. New melter designs are needed to correct this problem. Future efforts will be needed to improve performance and reduce canister production. Likely problems in immobilization will arise from feed delivery limitations that decrease the efficiencies of immobilization processing, reduce waste loadings, and increase the number of waste form canisters produced—increasing costs. In addition, glass melter failures will occur as more waste is processed and more systems come on line across the DOE complex. Failures will demand melter design improvements to mitigate future problems. Science and technology investments will be required to improve waste loadings, increase waste form disposal performance, and increase process throughput to meet schedule and cost baselines.

**Tank Closure.** Uncertainties in "how clean is clean", reliability of predictions of long-term contaminant migration and public exposure, and limitations in retrieval technology performance will drive the long-term issues in Tank Closure. As waste retrieval and processing proceeds, more and more sites will pursue tank closure to reduce mortgages. However, uncertainties in performance assessment models and transport data at some sites will make it difficult to establish acceptable closure criteria. Retrieval of tank waste heels or residuals will become difficult as more complex tanks undergo waste removal. Stabilization of waste residuals may need to consider means of incorporating higher volumes of waste while maintaining acceptable protection of the vadose zone, groundwater, and public.

## Problem Area R&D Program

Budget: FY98-$74.2M, FY99-$57.6M, FY00-$64.6M

### *Program Description*

The key problems faced by DOE sites, as indicated by their nearer-term submitted needs and longer-term program baseline summaries, fall into five technical areas reflecting the steps in HLW management: safe waste storage, waste retrieval, waste pretreatment, waste immobilization, tank closure, and the characterization and monitoring required for each of these process steps. Disposal of low-activity waste forms is also included in the immobilization area. The nearer-term investment strategy in each of these technical areas is described below. Longer-term research issues and objectives were described previously. Characterization and monitoring is discussed in the context of the other technical areas it supports.

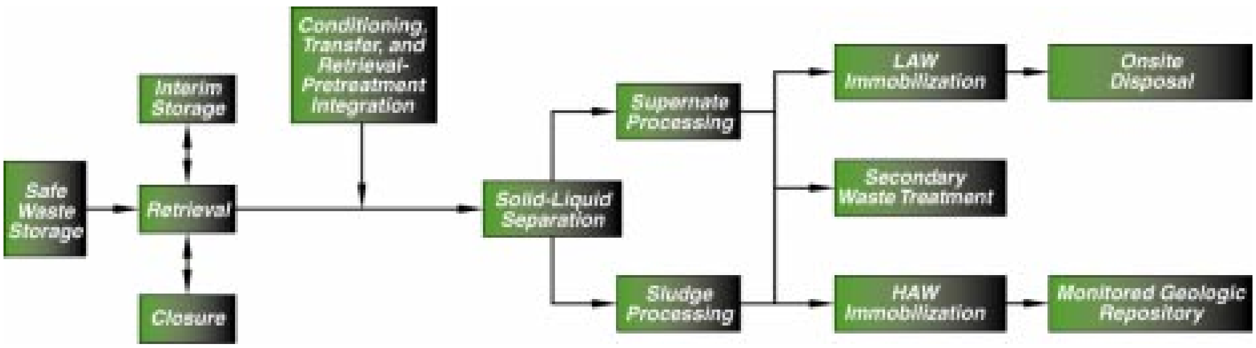


*Figure 3-4. Generic tank remediation flow sheet.*

Figure 3-4 shows the HLW remediation process. HLW will be retrieved from the tanks and processed (or pretreated) to separate it into a smaller amount of high-activity waste (which is costly to dispose) and a large fraction consisting of common chemicals contaminated with low levels of radioactivity. Both fractions will then be immobilized, creating durable solid wastes. The high-activity waste (HAW) will be shipped to the Federal geologic repository, while the low-activity waste (LAW) will be disposed onsite. The nearly empty tanks will be closed in accordance with regulatory agreements that are not yet established in most cases. HLW cleanup will take many years to complete; current project plans predict that all waste will be treated and tanks closed by 2046. In many cases, institutional management measures, such as land use restrictions and groundwater monitoring, will be applied following tank closure. DOE will make continued progress in waste tank closure, answer key technical questions, and develop more cost-effective alternatives by accomplishing the following near-term goals:

- Provide heel retrieval and characterization systems or technologies necessary to support the closure of 16 radioactive waste storage tanks by 2006. Efforts will demonstrate progress toward, and technology capability needed for post-2006 retrieval closure of the majority of remaining radioactive storage tanks. Near-term efforts will include two tanks each at Hanford, INEEL, ORR, and SRS.

- Support tank farm closure activities by developing and deploying screening and sampling tools for residual tank waste and leaked waste inventory assessments. Efforts will support the near-term schedules for tank closure, and establish the technical basis and benchmark process for full tank farm closure post-2006.

- Provide data deliverables, performance specifications, and hardware supporting deployment of improved waste mixing and retrieval system for double- and single-shell tanks by 2001 to support waste feed delivery to processing facilities. Efforts will establish the basis for planning more aggressive waste retrieval efforts to support full-capacity processing post-2006.

- Develop data and technologies to further DOE's ability to oversee and monitor privatization of designated tank waste remediation functions.

- Develop and deploy by 2001 sensors to monitor 1) tank corrosion and support tank life extension requirements, 2) waste processing, 3) waste transfer and retrieval, and 4) waste and immobilized waste storage. Near-term efforts will reduce mortgages and risks of waste storage and processing. Longer-term efforts will be required to ensure tank integrity many years past the design life of current systems.

- Develop and deploy technologies to reduce the volumes, including water-balancing techniques, of both high-activity and low-activity tank wastes.

- Improve waste loading for high-level vitrified waste at SRS and Hanford by 2001 and better understand melter glass chemistry to support long-term improvements in high-activity waste processing.

- Develop a technical basis for immobilized waste product performance at INEEL and Hanford by 2001 to support design efforts and early privatization efforts.

- Develop and demonstrate lower cost solutions to support waste processing needs, such as low-cost mixers, thereby reducing long-term mortgages.

- Identify issues and develop solutions to waste remediation technical gaps that may exist between the interfaces of retrieval, pretreatment, immobilization processes, and the closure function and final waste state.

**Safe Waste Storage**

Budget: FY98-$5.2M, FY99-$2.7M, FY00-$10.7M

**Objectives and Activities.** 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 to extend tank life, 2) improve tank ventilation to reduce costs, 3) improve waste characterization to support retrieval, and 4) reduce through source and recycle stream waste reduction the volume of waste entering the tank farm.

Extending Tank Life—The near-term goal to avoid 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 corrosion in tanks 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 non-destructive 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. Specific support provided by DOE to replace the baseline techniques include:

- Developing an electrochemical noise corrosion monitor, which is deployed through a tank riser, for use at SRS and Hanford.

- Deploying a Raman-based nitrate, nitrite, and hydroxide ($NO_2^-/NO_3^-/OH^-$) in-tank sensor for corrosion inhibitor concentration monitoring at SRS.

- Deploying NDE end effectors with a Light-Duty Utility Arm (LDUA) or crawler-based platform.

- Ventilating Tanks—DOE's goal is to reduce the cost of active ventilation of HLW tanks. Specific activities include:

  - Exploring and evaluating passive ventilation concepts for use in replacement of the active ventilation systems on specific waste tanks at SRS.

  - Selecting and demonstrating regenerable filter systems to replace high-efficiency particulate air (HEPA) filters within the existing active ventilation system. A commercial system will be procured for demonstration.

Characterize Waste—DOE's goal is to invest in tools and methods to characterize waste in situ to support sludge and supernate processing at SRS and ORR. Specifically, DOE's activities will:

- Deliver a weight percent suspended solids monitor for SRS use in sludge settling and decanting operations to ensure continued feed to DWPF and process evaporators.

- Deploy a sludge mapping system for ORR to determine the volumes and interface between supernate, sludge, and/or hard heel.

- Deploy nested-array fluidic sampler and at-tank analysis system into Hanford waste tank to support feed staging for waste treatment.

Reduce Waste Volumes—DOE's goal is to implement technologies to reduce source and recycle streams at SRS and INEEL. Specifically, DOE will:

- Assemble a treatment train of commercially available technologies to treat the DWPF recycle stream at SRS. Specifically, DOE will evaluate the use of a compact processing unit concept to avoid large capital expenditures for new facilities. DOE will also evaluate options for reducing mercury concentration in this stream, which would reduce the complexity of the treatment train.

- Deploy evaporator technology for SRS Consolidated Incinerator Facility.

- Design and evaluate the potential for direct waste stream immobilization and on- or offsite disposal as LAW to avoid a costly treatment process and avoid increased volumes of tank HAW requiring treatment at INEEL.

**Accomplishments:**

- Processed 22,000 gallons of liquid waste from ORR Melton Valley Storage Tanks (MVST) through the mobile, out-of-tank evaporator system freeing up additional tank waste storage space.

- Deployed LDUA in INEEL tanks for sampling and NDE inspection.

- Lessons learned from hot demonstration of first- and second-generation electrochemical noise (EN) corrosion probes being incorporated into probes for deployment at Hanford and SRS; new generation probe deployments planned for 1999 and 2000 at Hanford and SRS, respectively.

- Deployed laser-based Topographical Mapping System technology in the ORR Gunite tanks to measure the extent of concrete spalling of tank walls.

- Issued industry call for regenerable HEPA filter technology for SRS; selected two vendors and initiated work.

- Deployed fluidic sampler for SRS tanks and demonstrated multiple-depth concept for Hanford tanks.

- Deployed Laser Ablation Mass Spectrometer for tank waste compositional analysis and Near Infrared Spectrometry for moisture content analysis in Hanford analytical hot cells.

**Waste Retrieval**

Budget: FY98-$16.3M, FY99-$10.1M, FY00-$13.6M

**Objectives and Activities.** 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, 2) detect and mitigate leaks during retrieval, 3) transfer waste, and 4) monitor and control retrieval processes.

Mobilize Bulk and Heel Waste—Mobilizing bulk and heel wastes within a tank is required to remove materials for tank closure, treatment, and ultimate immobilization and disposal of the hazardous waste components. Mobilizing dense sludge, saltcake, and dry/hardened materials is particularly challenging and important for retrieval operations. Baseline methods for waste mobilization are mixer pumps and long-range, high water volume sluicing. The goals are to provide the following technologies and technical solutions to support priority retrieval needs at SRS, ORR, Hanford, and West Valley. Specific activities will:

- Deploy 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).
- Deploy power fluidic 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).
- Deliver and deploy Russian Pulsating Mixer Pump in ORR GAAT tanks.
- Demonstrate and deploy retrieval technologies for retrieval of small, horizontal tanks with limited access.
- Deliver recommendations for Hanford and SRS sludge retrieval.
- Select technology and design concept for Hanford C-106 heel retrieval.
- Issue tank retrieval specifications/recommendations for SRS Type I/II tanks.
- Retrieve tank waste from SRS HLW tanks.
- Demonstrate alternate mixing technologies for Hanford, ORR, and SRS.
- Recommend improvements to existing mixer pumps at Hanford and SRS.
- Transfer Russian chemical cleaning expertise for application at SRS.
- Sample SRS salt tank annulus to determine retrieval requirements and issue retrieval decision.

Detect and Mitigate Leaks—The goals are to provide retrieval methods that avoid leakage by controlling and minimizing water, provide leak detection devices that can rapidly output data to guide retrieval operations, and create strategies to mitigate leaks once detected during retrieval. To address this goal, activities will:

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

Transfer Waste—The goals are to deliver data and systems to reduce the risk during waste retrieval and waste transfers. Retrieved wastes need to be transferred, and may require monitoring and 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. Specific activities will:

- 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 DOE and private industry.
- Develop and deploy a waste conditioning compact processing unit (CPU) for monitoring and conditioning for safe transfer of GAAT waste to MVST.

Monitor and Control Retrieval Process—The goals are to support retrieval and transfer operations with appropriate monitoring systems to avoid process upsets. Specific activities will:

- Deploy on-line slurry monitor to support GAAT retrieval at ORR.
- Develop improved gas retention sensing system to avoid problems during retrieval of Hanford HLW tanks.

**Accomplishments:**

- Completed testing and demonstration of Russian-designed pulsating monitor technology for use in tank mixing and retrieval.
- Retrieved four GAAT tanks using Modified Light-Duty Utility Arm (MLDUA), Houdini, and Confined Sluicing technologies; work continuing on fifth tank with goal of retrieving all ten GAAT tanks.
- Deployed pipe cutting and capping technologies deployed by MLDUA to cut and isolate internal piping in GAAT tanks to remove obstructions and prevent in-leakage of additional water after completion of tank retrieval.
- Deployed Pulse Jet Mixers in ORR BVEST successfully removing 32,000 gallons of sludge waste from three tanks.
- Demonstrated extendible nozzle borehole miner technologies used in mining industry for retrieval of small, horizontal tanks and deployed Borehole Miner system in four

ORR Old Hydrofracture Tanks successfully removing all remaining sludges required to prepare the tanks for closure.

- Deployed Pulse-Air™ mixing technology at GAAT Tank W-9 to support mixing for transfer of waste to MVST facility.
- Completed sensor testing and integration of CPU skid for the GAAT slurry monitoring system.
- Completed SRS Tank 16 annulus sampling and completed lab analysis and performance assessment modeling.
- Completed sluicing nozzle testing and provided recommendations for sluicing operations at Hanford Tank C-106.
- Conceptual designs and tank interface requirements delivered by two vendors for Hanford Tank C-106 heel retrieval; selected preferred vendor/technology.
- Conducted technology exchanges with Russian tank waste experts to promote sharing technical knowledge of retrieval experience and transfer technologies.

**Waste Pretreatment**

Budget: FY98-$18.5M, FY99-$18.8M, FY00-$13.1M

**Objectives and Activities.** Investments in waste pretreatment must be fully integrated with waste immobilization, which receives feed from pretreatment processes, and waste retrieval, which provides feed to pretreatment. The pretreatment step is critical to reducing the volume of LLW and HLW products; this reduces disposal costs. Investments include: 1) preparing retrieved waste for transfer and pretreatment, 2) clarifying liquid streams through solid-liquid separations, 3) supernate processing to remove radionuclides, and 4) sludge processing to remove excess chemical species that either increase the volume of HLW or adversely impact the performance of the HLW form. In addition, pretreatment addresses Interim Storage issues associated with INEEL's calcination and subsequent calcine dissolution.

Prepare Retrieved Waste for Transfer and Pretreatment—The goal is to ensure retrieved wastes are ready for downstream processing. Specific activities will:

- Evaluate saltcake dissolution and concentrate re-precipitation phenomena in complex solutions using nonradioactive surrogates to upgrade thermodynamic models and support retrieval and storage operations at Hanford for privatization.
- Study dilution, leaching, and washing of Hanford sludge, in conjunction with sludge processing, 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.

Clarify Liquid Streams—The goal is to deliver data and technologies to meet ORR, SRS, Hanford, and INEEL needs for process selection. Specific activities will:

- Deploy cross-flow filtration system for treatment of MVST supernate.

Remove Radionuclides—This includes reducing the levels of cesium, technetium, strontium, or TRU to meet LLW disposal requirements onsite. The goal regarding radionuclide removal for alkaline wastes is to deliver improved cesium separations systems to reduce cost and technical risk at ORR and SRS. Specific activities include:

- Evaluate crystalline silicotitanate (CST) and other sorbents or extraction processes to develop and deliver an alternative processing system for salt disposition and provide cesium removal for the DWPF recycle stream (see Safe Waste Storage - Reduce Waste Volumes) at SRS.

- Deploy a modular CPU for cesium removal applying CST technology at ORR MVST facility.

- Deploy process monitor to detect and measure cesium in process effluents.

The goal for transuranic (TRU), cesium, and strontium removal from acidic wastes is to provide performance and engineering data to INEEL users on solvent-extraction and ion-exchange processes to confirm their baseline process assumptions, support the record of decision, and support Title 1 design. Specific activities will:

- Demonstrate TRU and strontium solvent-extraction processes at the INEEL with actual liquid wastes and dissolved calcine.

- Develop an integrated cesium solvent-extraction process for consideration as part of the INEEL flowsheet.

- Test alternative cesium and strontium separation processes to provide additional performance data to support flowsheet development and downselects.

Process Sludge—The goal is to provide Hanford with baseline processing data to support phase II privatization. Specific activities will:

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

Interim Storage—The goals are to provide data and technology to enable waste processing at INEEL. Specific activities will:

- Develop and pilot test an advanced calcination flowsheet that will handle the sodium-bearing wastes while minimizing the chemical additives, controlling volatilization and fines generation, and producing a calcine that is safe and effective to transport, retrieve, dissolve, and is compatible with immobilization.

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

**Accomplishments:**

- Processed over 30,000 gallons of ORR MVST waste effectively removing 1,142 curies of cesium-137 using CST ion exchange technology deployed in a modular CPU.

- Completed sludge washing studies using actual tank waste samples from Hanford tanks and completed analysis for leachate chemistry for removal of problem constituents (e.g. Chromium) to reduce waste volume and improve performance of immobilized waste product.

- Completed demonstration of cross-flow filtration (CFF) technology and delivered a CFF-based solid-liquid separation CPU for treatment of MVST waste in 1999.

- Completed dissolution studies on calcined waste and testing of the CFF-based Cells Unit Filter (CUF) technology for use in separating residual calcine solids from liquid waste to support development of a waste treatment flowsheet for Idaho.

- Tested analytical models for Hanford saltcake dissolution and applied technology to assist Hanford in evaluating options for mitigating saltcake crust growth issue in tank SY-101; performed confirmatory hot-cell analysis on actual tank waste samples.

- Completed cesium removal testing on actual tank waste samples from INEEL tanks to support waste treatment flowsheet development.

- Supported SRS HLW program by technical assistance and recommendation on technologies for replacement of the SRS in-tank precipitation process; participated in evaluation of alternatives and development of recommendations.

**Waste Immobilization**

Budget: FY98-$10.0M, FY99-$10.0M, FY00-$13.1M

**Objectives and Activities.** Waste immobilization includes LAW immobilization, HAW immobilization, and disposal of LAW and HAW. The LAW 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 LAW, ranging from grout to glass, and from onsite to off-site disposal. SRS is operating their saltstone (grout) LAW immobilization process. Hanford has selected LAW vitrification through a privatization contract. DOE's science and technology activities are focused primarily on INEEL's LAW immobilization for which a final solution has not yet been determined, and support to Hanford's privatization and onsite disposal of final LAW forms. Needs exist for product acceptance testing to ensure the LAW 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 immobilized LAW meets requirements.

Immobilization of the HAW streams at the INEEL, SRS, and Hanford is required to produce an acceptable HAW form for final disposal. Vitrification is the baseline methods for HAW immobilization. In addition to the vitrification processes, melter feed preparation, process monitoring, and process control methods are required to produce acceptable waste forms.

The baseline technology for HAW processing is vitrification at all of the tank sites with this process being operational at SRS and West Valley. At SRS, methods that can reduce the cost of operation are being identified and evaluated. Cost reduction can occur through optimization of waste loading that reduces the number of glass 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 Hanford, optimized waste loading and melter selection are considerations for developing the baseline to support phase II privatization, especially with regard to concerns about high chromium wastes and their compatibility with current melter designs and waste formulations. At INEEL, waste formulation 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 the acidic wastes at the INEEL is a key issue that must be addressed with both formulation and materials development and testing.

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.

Process LAW—The goals are to establish baseline processes for INEEL LAW immobilization and support Hanford privatization. Specific activities will:

- Support INEEL with LAW stream pretreatment and immobilization development for the FY99 ROD and Title 1 design for INEEL's unique waste streams.
- Develop data and technical methods for Hanford to ensure, through in-process quality assurance and possible testing methods, that the privatization vendor products meet acceptance criteria.

Process HAW—The goals are to reduce costs of HAW processes at SRS and to reduce the technical risks of HAW processing at INEEL and Hanford through process definition. Specific activities will:

- Optimize waste loading for components such as iron, aluminum, silicon, zirconium, and alkali cations in SRS and Hanford wastes, and determine solubilities in glass of minor components such as chromium, phosphate, halides, technetium, and actinides to optimize waste loading of these components.
- Establish glass compositions for INEEL's sodium-bearing and calcined wastes to avoid highly corrosive environments and produce acceptable waste forms.

- Test innovative and next generation melters for use at INEEL to ensure compatibility of wastes and materials of construction.

- Develop and demonstrate equipment improvements such as melter pour spout, improved melter designs, and improved remote operations for DWPF to reduce downtime and increase throughput.

- Review potential alternatives to large-scale HLW melters, processing systems, and facilities.

Dispose of LAW—The goal is to ensure that data to support the design of LAW disposal systems are available. Specific activities will:

- Provide technical data relating glass composition and waste form durability to support product acceptance and performance assessment analyses.

**Accomplishments:**

- Demonstrated stirred-melter technology to support pour spout improvement testing and improved melter designs for future DWPF operations.

- Delivered liquidus temperature data and recommendations for process control improvements to be implemented in the DWPF process control system to increase waste loading in glass canisters.

- Completed thermal denitrification and melter material testing and initiated glass formulation investigations to support development of Idaho waste immobilization flowsheet.

- Delivered data on grout versus glass performance and cost to support ORR in evaluating immobilization options for MVST waste.

- Demonstrated commercial grouting technology for sodium bearing waste at INEEL.

- Provided technical assistance to Hanford in evaluating data and risks for privatization of tank waste vitrification.

### Tank Closure

Budget: FY98-$7.7M, FY99-$5.1M, FY00-$3.4M

**Objectives and Activities.** 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, to prevent subsidence of a tank, collapse of the domed top, long-term migration of residual contaminants, or short-term release of residual waste contents due to catastrophic failure. Stabilization may encompass 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 has become a key element in the tank sites' baseline plans for reducing mortgage and accelerating cleanup. SRS is actively closing tanks, while ORR and the Hanford Site are preparing for future tank closure activities through GAAT Treatability Study and the Hanford Tanks Initiative (HTI), respectively. INEEL is exploring an accelerated schedule for tank closure and will be sampling tank residuals to support future closure decisions. Similarly, West Valley is evaluating closure options for their four storage and process tanks.

Investments in tank closure include advancements in grout formulations and delivery methods to reduce costs and 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 goal is to deliver the technologies and data to enable all four tank sites to proceed toward closure. The following are specific activities relating to this goal.

- Deploy the LDUA at INEEL to sample tank residuals, evaluate tank integrity, and support strategy development for accelerated tank closure (see Safe Waste Storage - Extend Tank Life).

- Develop and demonstrate vadose zone characterization tools for deployment with the cone penetrometer to support tank farm closure performance evaluations and development of retrieval performance criteria at Hanford.

- Develop retrieval performance objectives to support the determination of a closure basis at Hanford.

- Deploy characterization, retrieval, out-of-tank processing of retrieved waste, process monitoring, and in situ grouting systems at ORR GAAT to close the North and South Tank Farms by 2002. DOE will develop and deploy tools using the LDUA to isolate and plug tank penetrations (e.g., piping) and develop, test, and deploy grout formulations and grouting techniques to stabilize a gunite tank. Lessons learned from efforts at SRS in 1997 with Tanks 17 and 20 along with performance data on ORR grouting will support additional tank stabilization activities at SRS, Hanford, and INEEL.

- Grout and close smaller tanks at ORR and SRS through testing and deployment of improved multipoint grout injection methods.

- Sample and retrieve wastes from ancillary equipment, such as a tank farm evaporator at SRS to support closure of the remaining tanks and tank farm at SRS.

- Provide technical assistance to Hanford vadose zone planning and investigations.

**Accomplishments:**

- Completed grouting and isolation of SRS Tanks 17 and 20 to support closure; received approval of closure from South Carolina.
- Completed feasibility demonstration of the multi-point grout injection technology for ORR GAAT tanks.
- Issued draft closure alternative recommendations for Hanford for review and comment, including stakeholder review.
- Issued grout formulation and emplacement specification for stabilization of GAAT tanks prior to closure.
- Demonstrated LDUA sampler for Tank AX-104 deployment at Hanford.
- Demonstrated Cone Penetrometer deployment platform, multi-sensor probe, and multiple soil sampler technologies for Tank AX-104 vadose zone deployment at Hanford.
- Delivered technical assistance to Hanford by participating in vadose zone/groundwater project panel meetings and advisory reviews.

**Directed Science**

Budget: FY98-$16.5M, FY99-$10.8M, FY00-$10.6M

Within the High-Level Waste investment portfolio, DOE funds research that advances science to solve environmental problems associated with storage tanks containing highly radioactive wastes, which include organic and inorganic chemical compounds in solid, colloidal, slurry, and liquid phases. Five subcategories of needs were identified in the area of high-level waste:

- Characterization of waste, tanks waste, containers, piping systems.
- High-level waste retrieval.
- High-level waste treatment and remediation.
- Disposition of tank wastes.
- Separation processes for tank waste treatment and removal.

Between 1997 and 2000, 67 research projects will be funded for a total amount of $38.6 million. The most promising and applicable basic research projects will transition to applied research or more advanced stages of technology development. The present HLW directed research portfolio is concentrated in the scientific areas of actinide chemistry, analytical chemistry and instrumentation, engineering science, geochemistry, geophysics, hydrogeology, inorganic chemistry, materials science, and separations chemistry. The following is a brief summary of research projects that are in progress in each of the ten scientific areas.

- *Actinide Chemistry:* Projects include a multidisciplinary research program designed to analyze the problem of trivalent actinide and strontium speciation and solubility in HLW tank supernatants, and investigation of new fundamental information on the chemical behavior and speciation of uranium, neptunium, plutonium, and americium in simulated alkaline tank waste sludges and alkaline scrub liquors.

- *Analytical Chemistry and Instrumentation:* A focus on laser ablation techniques, mass spectrometry, and sensors and techniques, as applied to high-level waste investment needs listed above. A sample of projects being funded include ablation mechanisms and the effect of the physical and chemical states of the sample (e.g., valance state, impurity concentration, particle morphology, defect concentration, and presence of liquids) on the character of the particles produced by laser ablation; chemical stability of waste storage forms, primarily glasses, in extended geologic repository conditions with elevated temperatures; developing an array of chemically selective sensors, based on highly selective molecular recognition agents and fluorescence techniques, coupled to fiber optics, for the safe and cost-effective in situ characterization of HLW tanks; electrochemical techniques to explore the fundamental aspects of the general and localized corrosion behaviors of iron and carbon steel in alkaline environments, including stimulated DOE liquid waste; and, a multi-organizational research task to develop new real-time sensors for characterizing glass melts in HLW and low activity waste (LAW) melters, and to understand the scientific basis and bridge the gap between glass melt model data and melter performance.

- *Engineering Science:* Investments are being made in the categories of bubble mechanics and sonification, design, process and modeling, and diagnostics. Applications for this work include fundamental understanding of the interactions between gas bubbles and tank waste during barometric pressure fluctuations; develop models and a numerical tool to mechanistically predict mixing processes in large waste-tank volumes; comprehensive characterization of the relevant rheological properties under actual processing conditions to permit the monitoring and control of transport tank slurries; complex interactions among chemical reactions, associated slurry rheological changes, and non-Newtonian mixing in storage tanks and the associated mixing processes and provide a scientific basis for waste retrieval decision making; and lastly, using physical and chemical techniques to identify the magnetic constituents and radionuclides in the waste streams. This last project could lead to the effective use of superconducting open-gradient magnetic separation as a pretreatment technique for radioactive or mixed-waste vitrification feeds from DOE sites.

- *Geochemistry:* Investments in this area are specific to sorption and desorption research relative to HLW treatment and remediation, retrieval, and separation processes. Projects include providing a credible model for the release of radionuclides from residual sludge (sludge components that are the prime actors in retaining radionuclides will be identified and synthesized); integrate techniques from surface science and geochemical kinetics to measure the dissolution rate of quartz and silica glass in a series of single and mixed solute solutions over a range of variable pH and temperature. Findings from this project will establish quantitative relationships between silica reactivity and a number of solution chemistries that have never been investigated or are presently understood in only a qualitative sense.

- *Geophysics:* Develop and test a seismic method to image and characterize waste materials contained in tanks using complete seismic response including the normal modes, or "free oscillations." The method will be developed with the ultimate application to image and characterize waste materials inside the large underground storage tanks at Hanford.

- *Hydrogeology:* Investigate the causes and extent of nonuniform flow in the vadose zone, and its effects on the migration of contaminants leaked from single-shelled storage tanks at Hanford.

- *Inorganic Chemistry:* Directed research is being done in the areas of hydrothermal oxidation, multiphase/gaseous chemistry, and solid/solution chemistry. Within these categories, eight individual projects have been funded. The following is a sample of the work being conducted: application of hydrothermal processing to high-level wastes for enhanced chromium separation from sludges; controlling precipitation, scale formation, and cementation of existing insoluble particles by aluminum-containing phases; factors controlling the nature and extent of colloidal agglomeration, determine how agglomeration phenomena influence physical properties relevant to waste processing, and develop strategies for optimizing processing conditions via control of agglomeration phenomena; and lastly, solution chemistry of technetium in the waste tank environment as well as the stability of technetium in various waste forms.

- *Materials Science:* Under the materials science heading, there are four areas in which the directed research is focused, they are chemical and structural properties of storage materials, radiation effects on storage materials, surface chemistry, and waste materials. Applications for this work include advantages and limitations of producing a zeolite-containing waste form from calcined radioactive waste, i.e., the effect of processing variables, reaction kinetics, crystal and phase chemistry, and microstructure on their performance; phase equilibria and solid solution behavior of the constituents of high-level waste forms and to model that behavior; thermal and radiolytic aging of organic compounds in high-level wastes; atomic, microscopic, and macroscopic levels of radiation effects in glass and ceramics that provides the underpinning science and models for evaluation and performance assessments of glass and ceramic waste forms for the immobilization and disposal of high-level tank waste, plutonium residues and scrap, surplus weapons plutonium, and other actinides; use spectroscopies along with thermophysical heats of gelation to relate the microstructural physical and chemical properties of these concentrates to their macroscopic characteristics. With this better understanding of macroscopic characteristics, the DOE will be in a better position to safely store these wastes as well as to be able to better plan for their retrieval, pretreatment, and final disposal.

- *Separations Chemistry:* HLW directed research investments in separations chemistry are in three specific areas: catalyst chemistry and waste treatment, ligand design and ion-exchange, and technetium chemistry and separations. Projects include solubility measurements and spectroscopic characterization to study the speciation, dissolution and redox reactions of chromium under conditions relevant to high-level waste processing; separation of sodium hydroxide and other predominant sodium salts such as sodium nitrate from high-level alkaline tank waste; electroactive ion exchange materials to remove anionic contaminants from HLW wastes and process streams; prepare realistic simulant formulations for complexant-containing Hanford tank wastes, and use those simulants to determine the relative importance of various organic complexants and their breakdown products on the partitioning of important radionuclides. Successful completion will make it possible for scientists in academic and industrial laboratories to address tank waste remediation problems without the high costs and hazards associated with handling actual tank waste samples; another project addresses the questions of separating and concentrating radioactive components of tank wastes (such as lanthanide, actinide species, and technetium). If efficient separations can be devised, the total volume of HLW to be stored is reduced to more manageable levels.

## Budget Summary Table

(Dollars in thousands)

| Program Activity | FY 1998 Appropriation | FY 1999 Appropriation | FY 2000 Request |
|---|---|---|---|
| Safe Waste Storage | 5,200 | 2,700 | 10,700 |
| Waste Retrieval | 16,309 | 10,133 | 13,600 |
| Waste Pretreatment | 18,518 | 18,820 | 13,147 |
| Waste Immobilization | 9,950 | 10,015 | 13,100 |
| Tank Closure | 7,736 | 5,085 | 3,400 |
| Directed Science | 16,526 | 10,801 | 10,641 |
| ***Total*** | **74,239** | **57,554** | **64,588** |