INNOVATIVE TECHNOLOGY
Summary Report

DOE/EM-0449

SRS Tank Closure

Tanks Focus Area

Prepared for
U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

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DISCLAIMER

INNOVATIVE TECHNOLOGY

Summary Report

SRS Tank Closure

OST Reference #22

Tanks Focus Area

Demonstrated at
Savannah River Site
Aiken, South Carolina

MASTER

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INNOVATIVE TECHNOLOGY

Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

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SECTION 1

SUMMARY

Technology Summary

Approximately 90 million gallons of radioactive waste is stored in 271 U.S. Department of Energy (DOE) underground tanks. Many of these tanks are approaching the end of their design life. Sixty-eight of these tanks are known or suspected to have leaked waste to surrounding soils. Some tank contents have also reacted to form flammable gases. The waste inside these tanks must be removed, and the tanks must be closed in a safe and environmentally sound manner.

High-level waste (HLW) tank closure technology is designed to stabilize any remaining radionuclides and hazardous constituents left in a tank after bulk waste removal. Two Savannah River Site (SRS) HLW tanks were closed after cleansing and then filling each tank with three layers of grout. Figure 1 shows the monument marking the closure of Tank 20.

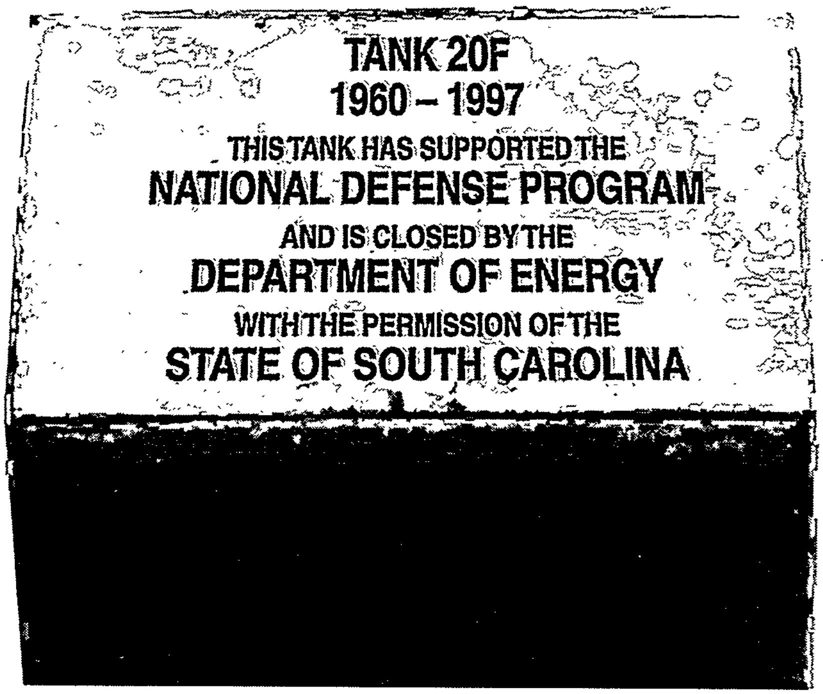

Figure 1. Tank 20 monument.

The first layer consists of a chemically reducing grout. The fill material has chemical properties that retard the movement of some radionuclides and chemical constituents. A layer of controlled low-strength material (CLSM), a self-leveling fill material, is placed on top of the reducing grout. CLSM provides sufficient strength to support the overbearing weight. The final layer is a free-flowing, strong grout similar to normal concrete.

After the main tank cavity is filled, risers are filled with grout, and all waste transfer piping connected to the tank is isolated. The tank ventilation system is dismantled, and the remaining systems are isolated. Equipment that remains with the tank is filled with grout. The tank and ancillary systems are left in a state requiring only limited surveillance. Administrative procedures are in place to control land use and access.

DOE eventually plans to remove all of its HLW storage tanks from service. These tanks are located at SRS, Hanford, and Idaho National Engineering and Environmental Laboratory. Low-activity waste storage tanks at Oak Ridge Reservation are also scheduled for closure.

Demonstration Summary

The two closed tanks are located in the F-Area Tank Farm at SRS near Aiken, South Carolina. Tank 20 was closed on July 31, 1997, and Tank 17 was closed on December 15, 1997. Forty-nine tanks, containing approximately 33 million gallons of radioactive waste with 480 million curies of radioactivity, remain to be closed at SRS.

Tanks 17 and 20 were prime candidates for closure. Bulk waste was removed from the tanks in the 1980s, each of the aging tanks had exceeded its design life, and neither tank contained much internal equipment. The closure process used is the result of continuous development and testing over a two-year period. This report covers the period of January 1996 through December 1997.

The DOE Headquarters Offices of Science and Technology (OST) and Waste Management (OWM) and the DOE–Savannah River Operations Office sponsored the tank closures.

Key parties involved in the work of actually closing the tanks include the following:

- Westinghouse Savannah River Company, High-Level Waste Division;
- Westinghouse Savannah River Technology Center;
- Bechtel Design and Construction; and
- George L. Throop Company of Pasadena, California

Other parties involved in this effort include the following:

- Construction Technology Laboratories, Inc. of Skokie, Illinois;
- Dr. Michael Roco, National Science Foundation;
- South Carolina Department of Health and Environmental Control; and
- United States Nuclear Regulatory Commission.

The two SRS tank closures described in this document are the first two HLW tanks to be officially closed. The primary objective of closing these tanks was to answer questions relating to HLW tank closure and to baseline an HLW tank closure path. As a result of the closures, future HLW tank closures can follow this baseline process and focus on improvements that will generate cost savings, efficiencies, and increased safety.

The HLW tank closure technology used in the closure of Tanks 17 and 20 is commercially available. SRS will continue to close other HLW tanks, implementing improvements and enhancements as the process continues. Tank 19 is scheduled for closure by the year 2003. SRS is developing a family of grouts with suitable properties and lower cost than the grout designs used on Tanks 17 and 20.

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Other
All published Innovative Technology Summary Reports are available on the OST Web site at http://ost.em.doe.gov under "Publications." The Technology Management System, also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST reference number for SRS Tank Closures is 22.

SECTION 2

TECHNOLOGY DESCRIPTION

Overall Process Definition

The goal of tank closure is to leave the tanks in a state where bulk waste contents are removed and residual contamination is stabilized. Prior to tank closure, acceptance criteria are established and agreed upon by regulators and stakeholders. These criteria are critical to the entire remediation process and help determine what technologies will perform well enough to meet the closure requirements. Implementation strategies are determined. Bulk waste removal is completed, and the tank is cleaned to the extent technically and economically practical. This process consists of water washing the tank to remove as much of the waste as possible. Any remaining waste is considered residual waste.

The HLW tank closure process is as follows:

- Residual waste is characterized.
- A method for stabilizing the residual waste is proposed.
- The proposed closure configuration is subjected to fate and transport modeling to evaluate compliance with overall performance objectives.
- A closure plan is prepared and submitted to appropriate regulators for approval.
- The tank is prepared for grout installation and final closure activities.
- After closure plan approval, residual waste stabilization proceeds.
- Grout installation is initiated. Three layers of grout are sequentially poured into the tank through tank risers.
  - The first layer is a sludge-entraining reducing grout that inhibits the spread of soluble radionuclides that could leach from the matrix to ground water. A dry grout-mixture is added as necessary to absorb stray water on top of the grout pour. Dry grout may also be added later to assist with contamination control and reduce hazards.
  - A second layer of CLSM is added to prevent overburden subsidence.
  - A third layer of a high-strength grout is poured to fill the dome space and deter intrusion.
  - The risers are filled.
- Final closure activities are completed:
  - Distribution pipes are cut and capped into the tank.
  - The tank is isolated from all utilities and services.
  - The tank ventilation system is dismantled.
  - Surface activities are completed.

The tank is left in a safe state so that only limited surveillance of the tank and ancillary services is required.

Figure 2 depicts the Tank 20 grouting process. This diagram illustrates the closure system deployed at Tank 20, the feeding of fresh grout from the grout plant directly into the tank through seven risers, and the tank in its final state.

Figure 3 shows the grout plant used for closure of Tanks 17 and 20. The George L. Throop Company of Pasadena, California supplied and operated this plant. The plant consisted of two separate continuous-feed volumetric mixers that delivered fresh grout into a pumping hopper. The grout pump fed the grout into a 5-in-diameter slickline that transported the slurry to the waste tanks.

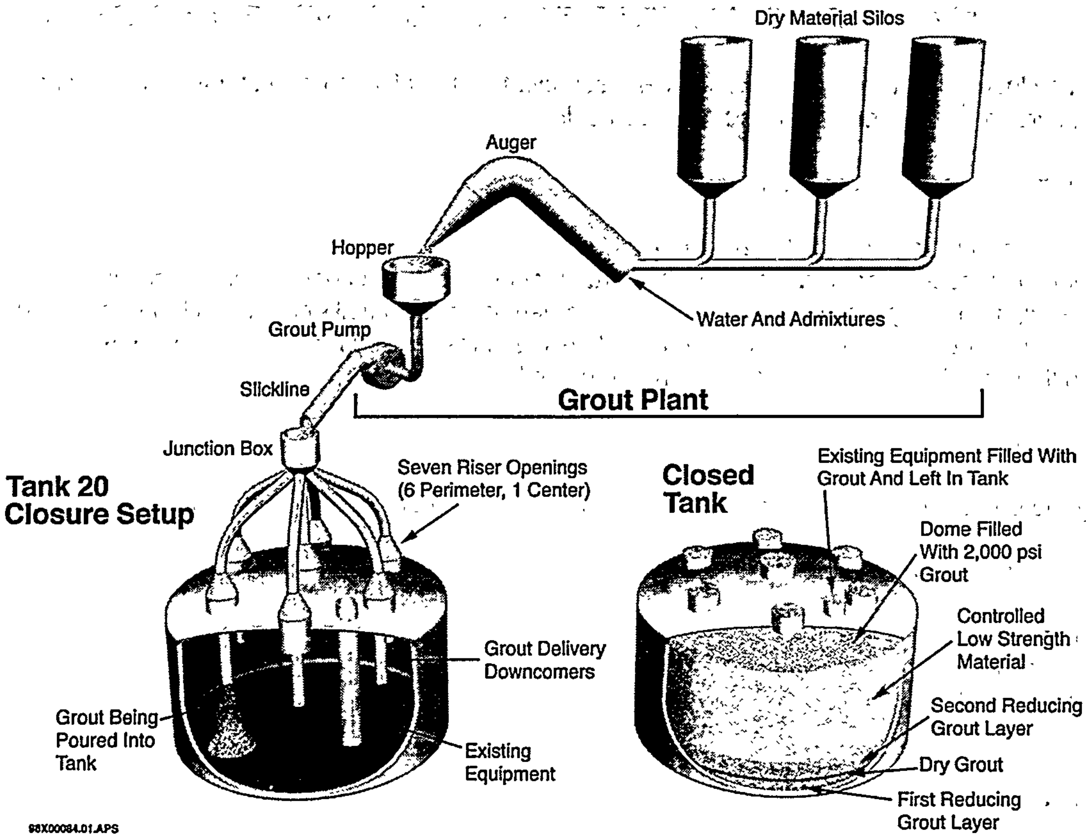

Figure 2. Tank 20 closure setup, grouting process, and closed tank.

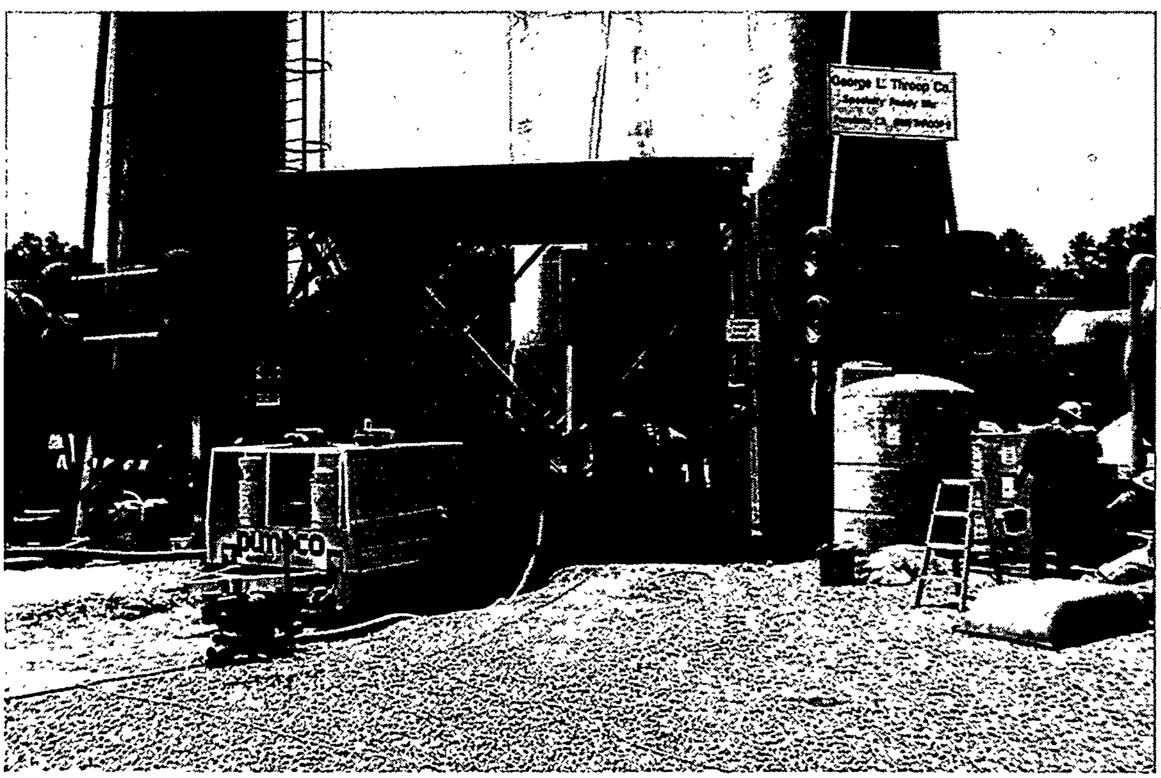

Figure 3. Grout plant used for closure of Tanks 17 and 20.

System Operation

HLW tanks closure requires operation of safety, sampling, retrieval, and grout installation equipment. System operation requirements are summarized below.

Operational Parameters and Conditions

- Bulk waste must be removed prior to closure.
- Remaining waste must be removed to the extent technically and economically practical.
- Retrieval, monitoring, sampling, and other equipment must be small enough to fit through the risers.
- The grout mixture must be flowable and self-leveling in the tank with minimal bleed water.
- Backfill materials must be similar to surrounding soil.

Materials Required

Grouting materials are required to produce and deliver reducing grout, CLSM, and high-strength grout.

Technical Skills Requirements

- General construction
- Quality assurance/quality control
- Waste characterization
- Heel retrieval
- Grout installation
- Requirements management
- Radiation protection
- Routine monitoring and inspection

Secondary Waste Consideration

- Secondary waste from heel retrieval and spray (water) washing must be kept to a minimum.
- Bleed water must be kept to a minimum.

Concerns/Risks

- Strong grout used to cap a tank must be able to deter an intruder from drilling into the tank.
- Grout must be evenly dispersed throughout the tank to prevent sludge from rising to the top of the grout. In the event that the tank ever looses structural integrity, floating or displaced sludge that settles near the tank wall could allow contaminant transport to the environment sooner than reflected in the fate and transport model.

PERFORMANCE

Demonstration Plan

This demonstration successfully closed two SRS HLW tanks. The new process was applied to Tanks 17 and 20 located in the F-Area Tank Farm. Tank 20 was closed on July 31, 1997. Tank 17 was closed later the same year on December 15. Both are Type IV tanks with

- primary carbon steel liner,
- capacity of 1.3 million gal,
- diameter of 85 ft,
- 44-ft, 10-in span from apex of the steel-reinforced, domed concrete roof to the tank bottom,
- 34-ft, 3-in span from sides of the dome to the tank bottom, and
- no cooling coils.

DOE's major objective for closing Tanks 17 and 20 was to provide answers to many of the technical and institutional questions relating to HLW tank closure and to baseline a HLW tank closure path.

Table 1 lists the major elements evaluated during the demonstration.

Table 1. Major elements to be evaluated during Tanks 17 and 20 closures

Element	Success criteria
Grout	The initial layer of reducing grout must accomplish the following functions: • Provide a chemically stable condition in which key waste constituent transport will be retarded. • Provide a mechanically binding condition in which the waste is entrapped and in contact or close proximity to the chemical reducing agent. • Be suitable for emplacement above ground. CLSM must produce minimum bleed water while maintaining flow.
Residual sludge	The final immobilized waste form must meet Nuclear Regulatory Commission Incidental Waste Criteria.
Worker	Individuals must be protected during operations.
Public	Drinking water doses in nearby waterways must be kept below 4 mrem/year for F-Area Tank Farm.
Intruder	The grout must deter intruders from accessing the buried tank waste.
Other	Closure must produce a stable environment at the disposal site.

Numerous technologies were developed and applied to the tank closures, including

- fate and transport modeling to represent the tank farm system,
- equipment and techniques for remote sampling of thin sludge layers,
- bulk waste removal and spray-washing for cleaning the tank,
- heel retrieval using aboveground transfer methods and systems for safely transferring waste between tanks, and
- in situ grout waste immobilization.

Bulk waste removal, which takes place prior to tank closure, was completed on both tanks in the mid-1980s. However, additional heel retrieval and cleaning were performed in Tank 17 to reduce the amount of sludge to an acceptable level for closure. Spray washing was selected as the technology for final cleaning.

Results

All the success criteria listed in Table 1 were achieved. CLSM and strong grout were successfully used to support the closures. Production rates were as follows:

- An eight-component reducing grout was produced at a maximum of 200–250 yd^3/day.
- CLSM production, with only three basic components plus admixtures, was as high as 700 yd^3/day.
- The reducing grout strength was more than 3,000 psi. Performance objectives required only a 500-psi strength.

Bleed-water generation was kept to a minimum due to the special formulations of backfill materials. Using a grout pumper truck on Tank 17 (rather than constructing a grout junction box as on Tank 20) reduced the cost of labor and materials. The coordination of grouting efforts saved time and money (i.e., the concrete batch plant did not have to repeatedly switch types of materials being produced).

Performance evaluations showed that residual contamination could safely be left in a near-surface burial. Samples showed that inventory estimates based on predictions were reasonable. Modeling revealed that plutonium-239, technetium-99, and selenium-79 were the main dose contributors. These constituents of concern were described in DOE 1997a and DOE 1997b.

Table 2 lists additional results for the individual tanks.

Table 2. Individual performance results for Tanks 17 and 20

Area/Topic	Tank 17	Tank 20
Residual waste stabilized (approximate amount)	• 2,200 gal of sludge • 200 gal of inert solids (concrete chips)	1,000 gal of sludge
Heel removal (approximate amount)	• 7,600 gal of sludge waste • 280,000 gal of liquid heel • Flygt mixers (4 and 15 hp) were used to suspend sludge heel • Water brushes sluiced suspended sludge toward diaphragm pumps for removal	• 25,000-gal liquid heel was removed in the 1980s when bulk waste removal was performed • 20,000 gal of liquid heel was removed prior to grout installation
Grout installed (approximate amounts)	• 6 ft (1,330 yd^3) of reducing grout • 28 ft (5,416 yd^3) of controlled low-strength material • 11 ft (1,307 yd^3) of 2,000-psi high-strength grout • 28 yd^3 of 5,000-psi high-strength grout in risers	• 518 yd^3 of reducing grout • 141,620 lb of dry grout material • 6,429 yd^3 of 5,000-psi high-strength grout in risers
Closure schedule	Closure activities began 9/22/97 and were completed 12/15/97	Closure activities began 4/24/97 and were completed 7/31/97
Time to complete closure activities	Approximately 3 months	Approximately 3 months
Date tank officially closed	December 15, 1997	July 31, 1997

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

As already stated, a baseline HLW tank closure process had not previously been established. Tanks 17 and 20 were the first HLW tank closures in U.S. history and were intended to establish a closure baseline. As a result of these closures, a template is available for other sites to use and improve upon.

Before the process used to close Tanks 17 and 20 was selected, a number of possible closure actions and configurations were considered. Simple models were set up and run for each of the cases. As part of the overall evaluation, closure options for each tank were evaluated to show conformance with performance objectives. Table 3 contains a list of closure process options or alternatives.

Table 3. Tank closure process options

	Option	Advantages	Disadvantages
1	• Clean tank to the extent practical. • Stabilize residual contamination by creating a grout monolith. • Stabilize tank by back-filling void space.	• Cost savings from modeling and testing to determine when acceptable level of residual waste is reached. • Operations and maintenance costs are eliminated. • Current hazards are eliminated. • Residual waste and the tank are stabilized. • Modeling results indicated a 24% decrease in total radiation dose at the seepline for grout fill versus sand.	• Potential for worker exposure. • Potential risks include hazards associated with increased truck traffic, spills of grout material, and tripping.
2	• Completely excavate tank and surrounding structures. • Decontaminate equipment. • Bury dismantled tank in a landfill or vault.	• Waste tank area may be left as an unrestricted area for future uses. Contaminated components could be buried in a waste disposal facility with better barriers to the migration of contamination than the current tank location.	• Costs are extremely high. • Potential for worker exposure is very high. • Tank must be transported to landfill/vault for burial. • Disposal of tank could create another zone of restricted use (restricted-use zone merely shifted, not eliminated).
3	• Clean tank to the extent practical. • Use no fill material. • Abandon in place.	• Initially, this option provides reduced exposure to workers. • Fewer actions are required on the front end to implement. • Short-term costs are reduced. • There is no initial impact on surrounding tanks or ongoing operations in the tank farm.	• There is no control of the tank. • The concrete in the tank roof and reinforcing bar will eventually fail. • The tank top will collapse. • Resulting damage would open pathways for contaminant migration. • Overall hazards, risks, and costs are increased.

Table 3. Tank closure process options (continued)

	Option	Advantages	Disadvantages
4	• Remove as much of the waste as possible. • Fill tank with sand.	• Sand is readily available and is inexpensive. • Sand would isolate the contamination, and prevent winds from spreading contaminants.	• Emplacement is difficult because sand does not flow readily into voids. • Over time, sand will settle in the tank, creating additional void spaces. • The dome would become unsupported and may collapse. • Sand is highly porous, and rainwater infiltrates rapidly. • Sand is inert and could not be formulated to retard the migration of contaminants. • Contamination levels in ground water would be higher than the preferred alternative.
5	• Remove as much of the waste as possible. • Fill tank with saltstone.	• This alternative would reduce the amount of saltstone landfill space required at SRS.	• Costs are higher than the selected alternative. • To implement, either two new saltstone-mixing facilities must be built or saltstone transport lines must be constructed. • Using saltstone would increase costs because it is contaminated with radionuclides. • Saltstone grout cannot be poured as fast as CLSM.

Technology Applicability

The Tanks 17 and 20 closure path can be generally applied to tank closures in radioactive environments across the DOE complex. These closures provide a template that other DOE sites can follow and modify as needed. For example, equipment and grouting formulas may require slight modification to match specific site and tank requirements. With a template to follow, sites can focus on improving the process.

Patents/Commercialization/Sponsor

The equipment and services required for implementation are commercially available. Two invention disclosures have been issued, and work is in progress on issuing a patent for the grouting materials. Since tank contents differ, a tank-specific grout formulation may be required.

The tank closure technology implemented at SRS is sponsored by OST and DOE-SR. Key parties involved with development and implementation of this technology are listed in Section 1 under Demonstration Summary.

SECTION 5

COST

Methodology

Prior to closure, a cost analysis was performed on the 24 tanks that are to be closed under the regulatory agreement between SRS, the South Carolina Department of Health and Environmental Control (SCDHEC), and the U.S. Environmental Protection Agency (EPA) Region IV. In the current federal facility agreement (FFA) waste removal plan and schedule, SRS committed to remove 24 HLW tanks from service by 2022.

Assumptions

Actual closure costs for Tanks 17 and 20 were approximately $5 million for each tank. Costs included materials, labor, engineering studies, and tests conducted to ensure safe closure. The cost analysis that follows was performed prior to the tank closures and is based upon the assumption that closure costs for the first 12 tanks will be $4.3 million each.

- All tanks can be closed utilizing the same methodology.
- The operational costs of a drained tank are the same as those of a tank in use; i.e., cost savings are not realized until the tank is closed.
- The total F-Area and H-Area Tank Farm budget is evenly distributed among the 51 tanks, providing a cost-per-tank basis for all HLW tanks at SRS.
- The budget can be modeled as 80% fixed costs and 20% variable costs.
- The tanks will be closed per the schedule contained in WSRC 1998.
- Variable costs are saved the year following the tank closures, and the fixed costs are saved after a four-pack is closed. (SRS tanks are arranged in multiple-tank complexes called "four-packs," "6-packs," etc.)

The closure costs for the first 12 tanks will be $4.3 million (M). The closure costs for the remaining 12 tanks will be $5.5M. (The difference in closure costs is due to variables such as cooling coils, residual heels, and higher activity levels.)

Cost Analysis

The total fiscal year 1997 operating budget for the F-Area Tank Farm is $47.0M, and the total fiscal year 1997 operating budget for the H-Area Tank Farm is $90.2M. The total budget for both F-Area and H-Area Tank Farms is $137.2M. The estimated operations cost of the 24 tanks to be closed is

- $2.69M/tank ($137.2M/51 tanks) and
- $64.6M estimated operations cost for the 24 tanks to be closed ($2.69M × 24).

Annual operating costs per tank using the 80% fixed cost, 20% variable cost assumption:

$2.15M fixed costs
$0.54M variable costs
$2.69M

All figures contained in the tables in this section are in 1997 dollars. Table 4 illustrates a sample calculation for the year 2008.

Table 4. Sample calculation (year 2008)

Item	Amount
Number of operating tanks	7
Baseline operating costs	$64.56M
Cost savings (variable)	$1.62M ($0.54M × 3)
Tank operating costs	$38.18M ($48.40M – $1.62M – $8.60M)
Tank closure costs (2 tanks)	$11.00M ($5.50M × 2)
Total cost savings (over baseline operating costs)	$15.38M [$64.56M – ($38.18M + $11.00M)]

Table 5 provides detailed cost calculations.

Table 5. Detailed cost calculations, in millions of 1997 dollars

Year	Tanks operating	Baseline operations costs	Operating costs	Tank closure costs	Cost savings (variable)	Cost savings (fixed)	Total cost savings
1997	24	64.56	64.56	4.30	0.00	0.00	(4.30)
1998	23	64.56	64.02	4.30	0.54	0.00	(3.76)
1999	22	64.56	63.48	4.30	0.54	0.00	(3.22)
2000	21	64.56	62.94	8.60	0.54	0.00	(6.98)
2001	19	64.56	53.26	4.30	1.08	8.60	7.00
2002	18	64.56	52.72	0.00	0.54	0.00	11.84
2003	18	64.56	52.72	0.00	0.00	0.00	11.84
2004	18	64.56	52.72	4.30	0.00	0.00	7.54
2005	17	64.56	52.18	12.90	0.54	0.00	(0.52)
2006	14	64.56	50.56	19.60	1.62	0.00	(5.60)
2007	10	64.56	48.40	16.50	2.16	0.00	(0.34)
2008	7	64.56	38.18	11.00	1.62	8.60	15.38
2009	5	64.56	27.96	16.50	1.62	8.60	20.10
2010	2	64.56	5.38	11.00	1.62	17.20	48.18
Totals	218	903.84	689.08	117.60	12.42	43.00	97.16

Table 6 shows cost savings in the years beyond the last tank closure.

Table 6. Post tank closure cost savings, in millions of 1997 dollars

Year beyond last tank closure	Cost savings
2011	64.56
2012	64.56
2013	64.56
2014	64.56
2015	64.56
2016	64.56
2017	64.56
2018	64.56
2019	64.56
2020	64.56
Total	645.60

Cost Conclusions

This cost analysis considers only the 24 tanks that are to be closed under the regulatory agreement between SRS, EPA Region IV, and SCDHEC. The total SRS cost savings is $97.2M (constant 1997 dollars) from the time the first tank is closed in 1997 until the last tank is closed in 2010. The cost savings 10 years beyond the last tank closure will be $645.6M (constant 1997 dollars).

SECTION 6

REGULATORY AND POLICY ISSUES

Regulatory Considerations

Regulatory requirements for implementation of the selected HLW tank closure process include

- State and EPA Regulations
- NRC Incidental Waste Criteria
- RCRA and CERCLA requirements

These requirements are described below.

State and EPA Regulations

SRS tank farms are regulated under the F/H Tank Farm Industrial Wastewater Operating Permit issued by the state of South Carolina (SC). The applicable regulation governing closure under this permit is SC Regulation R.61-82, "Proper Closeout of Wastewater Treatment Facilities." This regulation, however, is intended for ordinary wastewater facilities and provides virtually no guidance applicable to HLW tank closure.

The tank farms are also subject to an FFA among SRS, EPA, DOE, and SCDHEC. This agreement specifies that HLW facility closures at SRS must meet the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In the current FFA waste removal plan and schedule, SRS committed to remove 24 HLW tanks from service by 2022.

SRS regulatory drivers also include the Defense Waste Processing Facility Environmental Impact Statement (EIS) and Supplement, Savannah River Waste Management EIS, and Site Treatment Plan. The exact method of closure for each tank was described in closure modules approved by SCDHEC. Each closure module discussed the closure design, environmental effects, and the projected long-term dose to hypothetical receptors living in the area of the closure in future years.

NRC Incidental Waste Criteria

DOE determined that the material remaining in the tank systems at closure satisfied NRC criteria for "incidental waste."

RCRA and CERCLA Evaluation

The SRS Tank Closure Program is structured to be consistent with the comparative analyses performed as part of a Resource Conservation and Recovery Act corrective measures study and a CERCLA feasibility study under the FFA. A summary of how the closure technology addresses the nine CERCLA evaluation criteria follows.

1. Overall Protection of Human Health and the Environment: The demonstrated closure process provided a configuration that is effective in reducing and immobilizing residual wastes, providing for effective post-closure monitoring and maintenance and consistency with final tank farm remediation, and committing to implement appropriate land use controls for the long term.

2. Compliance with Applicable or Relevant and Appropriate Requirements: SRS completed a thorough search of regulations and identified all applicable or relevant and appropriate requirements (ARARs). SRS identified how each requirement applied to the closure and developed performance standards for the closure.

3. Long-Term Effectiveness and Permanence: The closure configuration, post-closure monitoring and maintenance, ultimate tank farm remediation, and appropriate land use controls will ensure long-term effectiveness. Grouting provides effective physical and chemical stabilization of the waste and tank system structures. Physical integrity of the configuration provides protection from inadvertent intrusion. Stability should be maintained for more than 1,000 years.

4. Reduction of Toxicity, Mobility, or Volume through Treatment: The closure process incorporated a technique to immobilize residual radiological and chemical contaminants of concern. Residual waste remaining in Tanks 17 and 20 was effectively immobilized by the physical and chemical stabilization provided by the reducing grout, CLSM, and strong grout stabilization scheme.

5. Short-Term Effectiveness: Individual radiation doses to workers are maintained as low as reasonably achievable through use of personal protective equipment and radiation work practices and controls. Associated air emissions are maintained within currently allowable limits.

6. Implementability: The closure process can be readily implemented using standard construction techniques. Necessary equipment, materials, and services are commercially available. Closure involves construction staff and craft personnel as well as a support infrastructure including roads, water supply, wastewater treatment, and waste management facilities and services.

7. Cost: Cost information is detailed in Section 5 of this document.

8. State (Support Agency) Acceptance: DOE coordinated closely with EPA, NRC, and SCDHEC in developing the SRS HLW tank closure strategy. SCDHEC, the state agency regulating the tank closures, approved the general closure plan, tank modules, and the actual tank closures.

9. Community Acceptance: Stakeholder support for the tank closures was very strong due to involving both regulators and the public from the beginning planning stages and throughout the project.

Safety, Risks, Benefits, and Community Reaction

Topics for this area are covered under Regulatory Considerations. Key benefits such as increasing environmental safety and generating cost savings are also discussed in Section 1 of this document under Demonstration Summary.

SECTION 7

LESSONS LEARNED

Implementation Considerations

This section highlights some key implementation considerations for the tanks closures. Lessons learned are detailed in "Savannah River Site High-Level Waste Tank Closure Lessons Learned" (1998).

Design and Tank Isolation

- Design considerations include drainage and spill control, interim leak detection, grout level indicators, riser use and management, disposal requirements, and grout pour sequencing.
- Proper isolation safely relaxes administrative burden.
- Ventilation requirements must be carefully considered.
- Due to limited tank access, grout must be able to flow from the tank center to the perimeter.

Backfill Materials

- All backfill material must be compatible with surrounding soil with respect to density and compressive strength.
- Technetium remains in oxide form in chemically reducing environments while plutonium and selenium remain mostly insoluble at highly alkaline conditions. A grout was developed that exploited these phenomena to stabilize the residual contamination.
- Silica fume and superplasticizer enable good flow and leveling of grout while avoiding segregation.
- Grout must be evenly dispersed throughout the tank to prevent sludge from rising to the top of the grout. In the event that the tank ever loses structural integrity, floating or displaced sludge that settles near the tank wall could allow contaminant transport to the environment sooner than reflected in the fate and transport model.
- CLSM is highly prone to bleed-water generation.
- Provide a separate water supply tank to allow for cooling or heating as needed.

Technology Limitations and Needs for Future Development

- A better selection of grout formulations is needed to simplify the grouting process and reduce cost. SRS has begun development of one grout formula that will replace the three different ones used in the Tank 17 and 20 closures.
- Spill containment and line plugging abatement plans are essential because grout will spill and must be managed appropriately.
- The precision and accuracy of closure models may need to be improved.
- Improved waste heel retrieval systems are being developed to reduce the cost and duration of tank cleaning activities and to minimize residual waste quantities.

Technology Selection Considerations

- Before selecting a closure option/alternative, the site and regulators must agree on performance objectives and how much waste can remain in the tank.
- Contents vary from tank to tank. Grouting formulas should be selected based on the best match for each waste type.

APPENDIX A

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APPENDIX B

ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
CAB	Citizens Advisory Board
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLSM	controlled low-strength material
DOE	U.S. Department of Energy
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FFA	federal facilities agreement
HLW	high-level waste
NRC	U.S. Nuclear Regulatory Commission
OST	Office of Science and Technology
SC	South Carolina
SCDHEC	South Carolina Department of Health and Environmental Control
SRS	Savannah River Site