ORNL/CP-98216

CONF-980905--

The Integrated Tank Waste Management Plan At Oak Ridge National Laboratory

Karen Billingsley
STEP, Inc.
1006 Floyd Culler Court
Oak Ridge, Tennessee 37919
(423) 481-7837

Cavanaugh Mims
U.S. Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, TN 37831
(423) 576-9481

Sharon Robinson
Oak Ridge National Laboratory
P.O. Box 2008 MS 6044
Oak Ridge, TN 37831-6044
(423) 574-6779

DISCLAIMER

DISCLAIMER

THE INTEGRATED TANK WASTE MANAGEMENT PLAN AT OAK RIDGE NATIONAL LABORATORY

Karen Billingsley
STEP, Inc.
1006 Floyd Culler Court
Oak Ridge, Tennessee 37919
(423) 481-7837

Cavanaugh Mims
U.S. Department of Energy
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, TN 37831
(423) 576-9481

Sharon Robinson
Oak Ridge National Laboratory
P.O. Box 2008 MS 6044
Oak Ridge, TN 37831-6044
(423) 574-6779

ABSTRACT

DOE's Environmental Management Program at Oak Ridge has developed an Integrated Tank Waste Management Plan that combines the accelerated deployment of innovative technologies with a aggressive waste transfer schedule. Oak Ridge is cleaning out waste from aging underground storage tanks in preparation of waste processing, packaging and final safe disposal. During remediation this plan will reduce the risk of environmental, worker, and civilian exposure, save millions of dollars, and cut years off of tank remediation schedules at Oak Ridge.

I. INTRODUCTION

U.S. Department of Energy (DOE) facilities have performed nuclear energy research and radiochemical production since the early 1940's. Oak Ridge National Laboratory (ORNL), located in east Tennessee, was constructed as a pilot scale plant for larger plutonium production facilities under construction at Hanford Washington during World War II. During these early research activities, little was known about the effects of exposure to radiation and other hazardous chemicals. Liquid radioactive waste was stored in underground storage tanks. Lower activity supernate was transferred to ponds for storage and settling before release in White Oak Creek. Contaminated solid waste was buried in pits and trenches.

Waste management practices changed as the power and hazards of this energy was better understood. Currently, millions of gallons of legacy radioactive liquid and sludge waste are contained in over 300 large underground storage tanks at DOE sites around the country. Management of this waste is a common problem.

II. REGULATORY DRIVERS

Federal and State laws govern the waste contained at these sites, and the associated regulatory agencies oversee related environmental activities. Risk, cost, and contamination pathway models prove the waste needs to be safely contained and disposed. Studies conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) at ORNL show that radioactive waste can be safely and efficiently managed.

Oak Ridge explored and tested the capabilities of new and off the shelf technologies as possible solutions for safe and cost effective tank waste remediation. Through teaming efforts with government agencies, private industry, universities and stakeholders, Oak Ridge is cleaning out waste from aging underground storage tanks in preparation of waste processing, packaging and final safe disposal.

III. THE INTEGRATED TANK WASTE MANAGEMENT PLAN

DOE's Environmental Management Program at Oak Ridge has developed an Integrated Tank Waste Management Plan that combines the accelerated deployment of innovative technologies with a aggressive waste transfer schedule. The plan will help Oak Ridge meet the State of Tennessee Commissioners unilateral order that requires treatment of transuranic sludge to begin by June 2002.

The Integrated Tank Waste Management Plan lays out a four part process consisting of:

- accelerated deployment of innovative technologies;
- integrated waste retrieval, waste conditioning, transfer, storage;
- tank closure;
- and the privatization of waste processing and packaging for off site disposal.

During remediation this plan will reduce the risk of environmental, worker, and civilian exposure, save millions of dollars, and cut years off of tank remediation schedules at Oak Ridge. Transferring this knowledge to other sites and facilities has the potential to save additional time and money, and greatly reduce the risks associated with the management of high-level tank waste across the DOE complex.

The Oak Ridge integrated tank waste management approach includes:

- retrieval of radioactive sludge from large underground storage tanks,
- conditioning and transfer of the retrieved waste to treatment facilities and intermediate storage tanks,
- separation of the liquid and solid waste,
- recycling liquid waste for waste retrieval activities,
- removing selected contaminants from bulk waste, waste concentration and
- waste stabilization and packaging for disposal.

IV. WASTE MANAGEMENT

Over the next four years Oak Ridge will retrieve, condition and transfer over 1 million gallons of radioactive liquid and sludge waste for final processing and disposal by the private sector. Plans call for a proposed waste treatment facility that will be located in Melton Valley at ORNL. The existing facilities under this plan include waste storage facilities, facilities generating new waste, and active waste management facilities. Some waste storage facilities under the integrated plan contain legacy waste. New waste is generated from isotope production for research and medical purposes. The waste under this plan is among the most hazardous on the Oak Ridge Reservation. Tank waste sampling and analyses have determined the wastes present a radiological hazard and contain Resource Conservation and Recovery Act (RCRA) toxins.

To prepare for the complex task of finding the optimum way to move large amounts of radioactive waste through the system for final disposal, Oak Ridge performed a technical evaluation looking from the bottom up, and built a mathematical model of the waste and the existing waste system. The waste was sampled and characterized, tanks were evaluated on their condition and capacity, and the operations of waste generator and storage facilities were reviewed. Waste operations were assessed including; collection, treatment and storage abilities. While studying the vulnerability of the existing system, Oak Ridge looked for alternatives to cost effectively optimize the system as a whole. Each type of facility has unique characteristics and needs (see table 1) that must be addressed in order to optimize the waste-handling plan. Oak Ridge assessed the needs and resources of their facilities, evaluated the existing and future waste volumes, and determined the skills and resources required to manage the waste safely and cost effectively. Through this effort a waste-handling plan was developed for waste generator facilities, legacy waste storage facilities, and active waste management facilities.

The Integrated Tank Waste Management Plan is a living document that will change as resources, additional waste, and new technologies are identified. Senior management must recognize the necessity and value of integrated systems planning. By envisioning the entire scope of radioactive tank waste management and utilizing an integrated systems approach, management can educate individual program and project managers about the "big picture" and show them how their individual project fits into an integrated plan and schedule. Everything that happens at the individual project level has the potential to affect the whole plan. By coordinating multiple projects and identify and allocate resources to safely optimize waste retrieval, treatment, transfer, volume reduction, and consolidation the potential exists to further reduce costs, schedule and worker exposure through an integrated plan.

V. NEWLY GENERATED WASTE

Waste generator facilities at ORNL are typically isotope production or research facilities. Pretreatment, or source treatment of newly generated waste will reduce radiological hazards and the volume of the final waste output before it enters the main waste management system. This waste management technique reduces risk and saves money on final waste disposal costs.

The Radiochemical Engineering Development Center (REDC) at ORNL is a valuable national resource that produces californium-252 for medical treatment and research activities. Waste generated at this facility is radioactive and requires proper storage and disposal. The REDC generates over 99% of the cesium and transuranic radionuclides, but only 10% of the waste volume. The pretreatment processes at the REDC will reduce radiological hazards associated with this waste, and reduce the processing and waste disposal costs that would occur if untreated REDC waste was mixed with waste from other generator facilities. Under this scenario the entire volume of waste would require treatment and disposal as transuranic waste.

Transuranic waste will be precipitated and removed by a solid/liquid separator. Liquid waste will progress through highly selective ion exchange resins that will remove cesium. The cesium and transuranic waste will be dried into a salt cake for disposal as solid transuranic waste.

Other waste generator facilities at Oak Ridge have benefited from source treatment. The Process Waste

Treatment Plant, the High Flux Isotope Reactor, and the Bulk Shielding Reactor generate 80% of new radioactive waste, but contribute insignificant amounts of radioactivity. These facilities are implementing source treatment and reducing the volume of their newly generated liquid low-level waste by more than 85%.

VI. ACCELERATED TECHNOLOGY DEPLOYMENT

Legacy radioactive waste is stored in various inactive and active facilities at ORNL. Under the Federal Facility Agreement (FFA) Tanks Program, small to medium sized inactive storage tanks are closed by removing them, or stabilizing them in place. In some cases residual waste needs to be retrieved from the tanks before isolating for final closure. The FFA Tanks Program has remediated 20 tanks to date.

Currently, waste retrieval activities are being performed in large single shelled waste storage tanks at ORNL. Oak Ridge is leading an accelerated deployment of innovative new and off-the-shelf technology in an integrated systems approach to tank waste remediation. This approach emphasizes safety, and optimizes lessons learned by starting operations in lower risk tanks. Operators assess the systems and procedures and can improve them, if necessary, before they progress to higher risk tanks. Four integrated suites of technologies are being deployed to retrieve waste from various storage facilities at Oak Ridge. Four other systems will be used to prepare waste for transfer and final processing and disposal.

The Oak Ridge's Environmental Management Program is demonstrating waste retrieval technologies with the ability to clean out tanks of various shapes and orientations. The Radioactive Tank Cleaning System (RTCS) is dislodging sludge heels and cleaning contamination from the walls and floor of large gunite tanks. Bulk sludge removal was successfully performed in large cylindrical tanks using a combination of fluidic pulse jet mixing, manual sluicing, and acid dissolution. Medium sized tanks will be cleaned with a combination of high-pressure sluicing, using a remotely operated articulated extendable nozzle for bulk sludge retrieval, and a small remotely operated vehicle will perform final waste removal operations with a vacuum.

The demonstrations are showing that waste can be safely removed from underground storage tanks, but also show a need for increased reliability and capacity of the waste retrieval equipment in order to speed up remediation efforts. Equipment modifications and improvements, and the addition of some key equipment for waste conditioning, treatment, and transfer are part or Oak Ridges integrated plan to safely prepare this waste for disposal.

VII. WASTE RETRIEVAL ACTIVITIES

A. Inactive Facilities

1. The Gunite Tanks

The Gunite tanks were constructed in 1943 to serve as temporary waste storage tanks for the Manhattan Project. Wire mesh and reinforcing rod frames were sprayed with layers of Gunite, a Portland cement and sand mixture. These large domed underground waste storage tanks are located in two tank farms near the center of ORNL's main plant area in the Bethel Valley watershed. Most of the accumulated liquid and solid waste was removed from the six larger 50 ft diameter tanks in the early 1980's, yet approximately 37,000 Ci are in the 350,000 gallons of liquid and 87,000 gallons of sludge waste that remain in all of the gunite tanks. Currently the tanks contain over 40% of the ORNL transuranic sludge inventory. Analyses show the sludge characteristics vary from tank to tank. Soft and hard layers of sludge have been encountered, large chunks of waste and other debris have been identified. Tank conditions vary and some tanks show signs of deterioration.

Waste retrieval and tank cleaning were successfully demonstrated in two 25 ft diameter tanks in the North Tank Farm with the RTCS. The RTCS can dislodge sludge heels, and remove waste and contamination from the tank floors and walls. In preparation of waste retrieval activities in the six larger 50 ft diameter tanks in the South Tank Farm, the RTCS was modified to increase its capacity and reliability.

The improved system includes the existing RTCS (see spectrum 98 paper titled *Large Underground Radioactive Waste Storage Tanks Successfully Cleaned at Oak Ridge National Laboratory*) with an improved waste dislodging and conveyance system, or WD&C, and Houdini II remotely operated vehicle. The improved WD&C will have increased capacity and reliability that will speed up waste retrieval operations. The Houdini II remotely operated vehicle incorporates additional payload capacity and improved hydraulics that will increase the reliability of the system. An added high-pressure pump will increase the systems wall scarifying pressure to 35,000 psi. This will allow a 1/8 in layer of gunite that contains most of the fixed tank contamination, to be removed from the interior tank walls.

In order to prevent wear and tear on the RTCS, two electrically powered FLYGT mixers will be suspended on supporting shafts in the larger gunite tanks. Before sludge heel retrieval operations begin, bulk soft sludge will be suspended the mixers and then removed. This action will lower the dose rate in the tanks, and reduce the amount of process water required to remove the remaining sludge heels.

Tank W-9 will serve as the holding tank for retrieved waste in the South Tank Farm before the waste is transferred to the Melton Valley Storage Tanks (MVST) for final consolidation. An array of Pulsair mixers will be installed in this tank to keep solids in suspension until a scheduled waste transfer occurs under the integrated waste management plan. This reliable system has no moving parts and will significantly reduce maintenance and waste retrieval costs in the holding tank.

A skid mountable Sludge Conditioning System will be used in the South Tank Farm to insure proper particle size distribution, and concentration of the waste slurry transferred from the tanks. The system will include an in-line grinder to reduce the size of solid particles. A solids classifier limit the size of particles leaving the waste consolidation tank and real-time solids monitors will measure particle size distribution in-line, which will help to prevent clogging the waste transfer lines.

The combined use of the waste retrieval and conditioning systems during the Gunite Tanks Remediation Project operations will reduce worker exposure to radiation and further reduce the baseline cost. Waste removal activities will be completed in the South Tank Farm in July 2000.

2. The Old Hydrofracture Facility Tanks

The Old Hydrofracture Facility was constructed in 1963 for the permanent disposal of low level radioactive waste. The waste was mixed with grout and injected into nearly impermeable shale formations about 1,000 ft underground. The operation was shut down in 1980 and today, five underground storage tanks remain at the site. The OHF tanks are cylindrical with capacities ranging from 15,000 to 25,000 gallons. The carbon steel tanks were buried horizontally in an unlined pit 13 feet underground. The OHF tanks have been upgraded and sampled to prepare for waste removal operations.

The tanks contain about 10,000 gallons of transuranic mixed waste sludge, and 43,000 of radioactive liquid. . Thirty thousand curies of mostly strontium-90 are contained in the OHF tanks. The sludge consistency ranges from soft thick mud to very hard and dense. Harder chunks were visible in the sludge. Dose rates of up to 50 R were recorded from tank samples.

The Borehole Miner uses high pressure sluicing deployed by an articulated extendible nozzle to dislodge the radioactive sludge and suspend it in the liquid waste. Inserted vertically through a tank access riser, the nozzle can tilt up to 90 degrees and extend 10 ft out in the tanks. Submergible pumps will remove suspended waste and sluice water from the tanks. Tank liquid will be recycled through a pumping system and used to scour the interior of the OHF tanks. The smallest tank at the site will be used as a holding tank for recycle liquid waste used for sluicing operation and will also facilitate waste transfers to the MVST.

A remotely operated vehicle known as the Scarab IIa will be deployed after the tank sluicing activities. The vehicle is equipped with inspection and sampling tools and will facilitate residual sludge heel waste retrieval. The Scarab IIa will manipulate a jet pump that will remove residual waste from the OHF tanks. The equipment is required to remove 95% of the sludge from the tanks. The combined use of the two technologies in the OHF tanks will result in effective tank waste removal. The remotely operated vehicle will provide valuable information on the condition of the tanks and any remaining waste to prepare for final tank closure. Tank waste removal activities are scheduled to begin in May and continue through July 1998.

B. Active Facilities

1. The Bethel Valley Evaporator Service Tanks

The Bethel Valley Evaporator Service Tanks (BVEST) are located in ORNL's main plant area. Five cylindrical stainless steel storage tanks are located in two concrete underground vaults, and measure 12 ft in diameter and 61.5 ft long. This active waste management facility concentrates dilute radioactive liquid low-level waste. The BVEST tanks play an important role in the integrated waste management plan at Oak Ridge. This active waste management facility will serve as interim storage for waste transferred from waste retrieval operations and waste generator facilities. After excess liquid is evaporated from the waste it will be transferred to the MVST for additional waste treatment and consolidation.

Precipitants from the cooled evaporator waste had formed a sludge layer on the tank bottoms 2 .5 to 5 ft. deep. The tanks have a complex internal configuration with six 3 in. diameter mixing nozzles and other equipment extending vertically down into the tank along the centerline. Radiation levels up to 27 R per hour have been detected in and around the tanks. Three tanks were sampled and contained about 27,000 gallons of sludge whose total activity measured around 11,000 Ci with the greatest activity coming from strontium-90.

A Fluidic Pulsed Jet Mixing System, was installed at the BVEST site in July 1997 to perform bulk sludge retrieval. The system consists of seven integrated equipment skids. A jet pump draws liquid through the 6 existing tank nozzles into 6 charge vessels installed in the existing tank pump and valve vault. The charge vessels are pressurized by the jet pump's dual venturi system forcing the liquid back into the tank causing a mixing action. The equipment has few moving parts and is reliable for bulk sludge removal. Waste transfers occurred immediately after a series of jet mixing campaigns. Jet mixing was effective for the bulk sludge removal.

A manual sluicer was used in one of the tanks to pushed the residual sludge heels toward the waste transfer pump. The combined efforts removed about 95% of the sludge from the tank. Acidic liquid waste was added to this tank after analysis indicated that additional sludge could be dissolved with a nitric acid solution. Another mixing campaign was conducted, and following the final waste transfer it was estimated that about 98% of the waste was removed from the tank.

A quick hose change out allows the mixing system to be connected to other tank. The pulse jet mixing system was used in two additional tanks with added acid waste to enhance the waste retrieval capabilities of the system. The pulse jet mixing system effectively removed about 95% the bulk waste from the tanks without requiring manual sluicing.

The demonstration was successfully completed in the W-tanks in May 1998. Modifications to the system will increase its efficiency. Rotating nozzles will improve its mixing capability, and an in-line solids monitor could facilitate waste transfers during sludge mobilization activities. Tank upgrades were completed at the BVEST C-tanks in preparation of the installation of a pulse jet mixing system with rotating nozzles. Waste removal activities were begin the these two tanks upon completion of the equipment installation.

VIII. WASTE CONSOLIDATION

A. Melton Valley Storage Area

The MVST became operational in 1980 to provide storage for concentrated liquid low-level waste in eight 50,000 gallon stainless steel tanks that are 12 ft in diameter and 61.5 ft. long. The tanks are located in two adjoining stainless steel lined concrete vaults equipped with leak detection systems. The tanks play an important role in ORNL's waste management by storing a majority of the liquid low-level waste and transuranic sludge. The volume of sludge and liquid waste, and their physical, chemical and radiological properties vary slightly from tank to tank. The waste volumes in the tanks will continue to change as waste is retrieved from the Gunite, BVEST and OHF tanks. Waste transfers to the MVST from retrieval operations began in September of 1997.

Six additional tanks have been installed in the Melton Valley Storage Area and are known as the Melton Valley Storage Tanks – Capacity Increase (MVST-CI). The large tanks will come on line in September, 1998 and will provide an additional 450,000 gallons of storage capacity.

IX. WASTE TRANSFERS AND WASTE TREATMENT

All wastes from retrieval operations and waste generator facilities are transferred via doubly contained pipelines installed in compliance with the FFA. The Integrated Tank Waste Management Plan calls for waste treatment to separate liquid and solid waste, remove selected contaminants, and significantly reduce the waste volume before final waste processing and disposal.

A Solids/Liquids Separator will remove excess liquid from the waste. The waste streams will be split at this point. Separated liquid waste will go through a cesium removal system. Ion exchange columns will remove up to 95% percent of the cesium contained in the liquid waste, greatly reducing its radioactivity. An out-of- tank evaporator will reduce the volume of the decontaminated liquid. About 1.5 million gallons of waste will be treated during this time. Approximately 25,000 curies of cesium will be removed from this waste and the volume will be reduced by around 57%. The remaining waste will be consolidated in the MVST. Treatment for all waste retrieved from generator, legacy, or active waste storage facilities is scheduled to begin by June 2002.

IX. CONCLUSION

Oak Ridge's Integrated Tank Waste Management Plan calls for all transuranic waste to be transferred to the MVST by June 2000. DOE is committed to conducting these waste transfers safely and plans to meet the State of Tennessee mandate that calls for treatment of transuranic waste to begin by June 2002. Enlisting the services of a private contractor to construct and operate a waste treatment and processing facility further evidences DOE's commitment. The necessity and value of an integrated systems approach must be recognized as a viable solution for radioactive waste management. The Oak Ridge approach includes accelerated technology deployment, waste retrieval, treatment and consolidation. The integrated plan shows a potential cost avoidance of $350 million and will reduce the tank waste retrieval schedule by more than 8 years. The application of these technologies and principles at the Hanford, Savannah River and Idaho sites has the potential to save millions of dollars, reduce the clean-up schedules, and reduce worker and environmental exposure during the clean-up of larger, more hazardous radioactive waste storage tanks.

The success of the plan has been demonstrated as Oak Ridge performs waste retrieval activities that other sites are beginning. Funding must continue for waste retrieval and tank closure activities. Funds should be allocated for the proposed waste treatment facility in Melton Valley. This facility is necessary to meet the accelerated regulatory drivers for safe waste processing, and final waste disposal at the Waste Isolation Pilot Plant, or Nevada Test Site.

Oak Ridge has come full circle from its original purpose as a pilot scale operation for larger facilities. Oak Ridge again serves as a pilot operation for tank waste clean up and is leading the way in the safe and cost effective retrieval, processing, treatment, packaging and disposal of radioactive waste.

Table 1. ORNL Waste Handling Facilities

Facility Type	Need	Solution	Special Concerns
Waste generator facilities	• Reduce the volume and radioactivity of newly generated waste.	• Source treatment and pretreatment of waste before it enters the main waste management system	• Must comply with FFA for RCRA underground storage tank compliance
Inactive Legacy Waste Storage Faclities	1. Retrieve waste from aging underground storage tanks. 2. Recycle liquid waste for waste retrieval 3. Waste treatment and volume reduction before final waste consolidation 4. Tank Closure	• Improved retrieval systems • Waste conditioning • In-line solids monitors	• Condition of tanks • Coordination of waste transfers during waste retrieval process • Worker safety and exposure • Cost effectiveness • Must comply with FFA, RCRA and CERCLA
Waste Treatment Facilities	• Optimize treatment capacities to reduce volume and radioactivity during waste consolidation • Optimize final waste forms for ultimate disposal at WIPP or NTS • Equipment maintenance	• Solid/Liquid separation • Cesium Removal • Evaporation • New storage tanks (online 9/98)	• Worker safety and exposure • Cost effectiveness • Must comply with NPDES and RCRA treatment permits

Table 2 - ONRL Facility Waste Transfers

Facility	Sludge Volume (Gallons)	Supernate Volume (Gallons)	Estimated Waste Retrieval Liquid (Gallons)
Newly Generated Waste			
REDC	0	15,000/yr	15,000/yr
Other s	0	500,0000/yr	500,0000/yr
Inactive/Legacy Waste			
GAAT	87,000	180,000	247,000
OHF	9,800	43,000	42,900
Active/ Consolidation			
BVEST	25,600		230,000
MVST	94,900	215,000	
MVST-CI			