THE EVOLUTION OF LOW-LEVEL RADIOACTIVE WASTE (LLW) DISPOSAL PRACTICES AT THE SAVANNAH RIVER SITE COUPLED WITH VIGOROUS STAKEHOLDER INTERACTION

W. T. Goldston, E. L. Wilhite, J. R. Cook
Westinghouse Savannah River Company
Aiken, SC 29808

V. W. Sauls
U. S. Department of Energy
Savannah River Operations Office
Savannah River Site
P. O. Box A
Aiken, SC 29802

ABSTRACT

Low-level radioactive waste (LLW) disposal practices at SRS evolved from trench disposal with little long-term performance basis to disposal in robust concrete vaults, again without modeling long-term performance. Now, based on an assessment of long-term performance of various waste forms and methods of disposal, the LLW disposal program allows for a "smorgasbord" of various disposal techniques and waste forms, all modeled to ensure long-term performance is understood.

New disposal techniques include components-in-grout, compaction/volume reduction prior to disposal, and trench disposal of extremely low activity waste. Additionally, factoring partition coefficient (Kd) measurements based on waste forms has been factored into performance models.

This paper will trace the development of the different disposal methods, and the extensive public communications effort that resulted in endorsement of the changes by the SRS Citizens Advisory Board.

INTRODUCTION & BACKGROUND

In 1994, Savannah River Site (SRS) began disposal of low-level waste (LLW) in large, robust concrete vaults. At that time, the Department of Energy (DOE) LLW program was evolving from shallow land disposal in trenches to an assumption that vaults would be the only acceptable technology for LLW disposal in the humid environment of the eastern USA. Prior to the 1980s, DOE requirements focused on protecting the public from exposures of more than 100 millirem per year; however, the focus began to change in 1982 when the Nuclear Regulatory Commission (NRC) issued 10CFR61 defining acceptable, commercial LLW disposal standards.

The notion of groundwater protection and waste form performance was presented by the Environmental Protection Agency (EPA) in 1984, and as a result, the Oak Ridge Environmental Impact Statement (EIS) for LLW trench disposal was withdrawn because the EPA's voiced concerns about potential groundwater quality impacts. As a result, Oak Ridge decided to move to concrete tumulus disposal similar to the LLW disposal program in France. More attention was paid to groundwater protection and vaults as an appropriate disposal method when the Regional Compact Host States banned trench disposal in their efforts to design commercial LLW disposal sites. In addition, in 1985, EPA published a draft rule (40CFR193) that focused on groundwater protection.

In 1987, DOE-Headquarters (HQ) issued a directive to its field activities to separate LLW from the environment at humid sites. At the SRS, work was proceeding on an EIS for groundwater protection that specified vaults (and trenches) as a result of the HQ directive. However, no long-term analyses of waste form and disposal site performance had been conducted or required. The assumption was that robust vaults would afford more than adequate protection for LLW disposal.

In 1988, DOE issued new requirements for LLW disposal in DOE Order 5820.2A "Waste Management." A long-term Performance Assessment (PA) was mandated to allow LLW disposal and the performance objectives that were required to be met included groundwater protection.

The SRS disposal vaults were being designed before the PA was required, and were constructed before the PA was completed. The design objectives, therefore, assumed that stakeholders would not accept trench disposal, and the design features were developed to ensure acceptance in the National Environmental Policy Act (NEPA) process. For example, it was assumed that a barrier must exist between the waste and the environment. With concrete as the most practical barrier, it was believed that water intrusion would be minimized and a future closure cap supported.

At the time the disposal vaults were being designed, SRS did not have an aggressive public involvement program in place, so no attempt was made to fully inform or educate the public on these issues, except through the EIS public comment process.

The PA work was conducted after the vaults were designed; therefore, the PA actually analyzed the vault's performance instead of defining vault design criteria. As the PA was concluded, and vault operation began in 1994, disposal of large volumes (one million cubic feet per year) of slightly contaminated soil was questioned by SRS engineers and scientists. Since much of this soil was only suspected of contamination, it was concluded that placing essentially "clean" dirt into these extremely robust vaults was not cost effective. As a result, the PA scope was expanded to consider trench disposal of soil either slightly contaminated or suspected of contamination. As a result of the PA analysis for soil, it was determined that much of the SRS LLW with low radionuclide concentrations could be disposed in trenches in an environmentally sound manner. For the first time, the technical basis for long-term performance of a LLW form was understood, and the appropriate disposal method could be selected based on cost as well as environmental and technical performance. Cost of disposal in vaults was four to five times higher than trench disposal because of high capital costs required to construct a vault. The task to gain acceptance and approval for the more cost-effective and environmentally safe method was obvious.

DEVELOPMENT OF NEW DISPOSAL TECHNOLOGY AND STAKEHOLDER ACCEPTANCE

By 1994, the SRS stakeholder community through the Citizens Advisory Board (CAB), was becoming involved in reviewing and commenting on the SRS radioactive waste program, and was well aware of LLW disposal in vaults. The SRS stakeholder community was also very aware that past disposal of LLW in trenches resulted in tritium contamination in the groundwater that was above drinking water standards. If disposal practices were to be changed to less costly alternatives, the stakeholders would have to agree that the new disposal methods would be protective of the environment.

The first task was to inform and educate the stakeholders about the technical complexities of performance assessments and LLW disposal regulations. A strategy was developed and implemented to gain stakeholder acceptance by using a systems engineering approach and public interaction tools.

Building Knowledge Base

The program to educate stakeholders began in 1997, by briefing the CAB on the LLW disposal technical basis, the PA, and the waste forecast. The CAB is comprised of citizens from the communities nearby and down river of the SRS as well as non-voting members from the EPA and the South Carolina Department of Health and Environmental Control (SCDHEC). As a result of several briefings in 1997, CAB members expressed their concern about the cost of the 25 vaults that were predicted to be built to dispose of all LLW over the next 20 years. CAB members were pleased to hear that through operations such as volume reduction and the prudent use of trench disposal for soil, there was a potential that all the expensive vaults originally forecast may not be needed. It was extremely important in SRS's strategy for the CAB to understand and gain confidence in the SRS's ability to model waste performance over the long term, and to set and implement limits for waste disposal bases on that modeling that are protective of the environment.

To build on the presentations concerning the PA, in 1998, a series of discussions on the Composite Analysis (CA) were begun. The CA was conducted as a result of a DOE requirement to analyze the impact that other nearby sources of radioactive contamination may have on ongoing LLW disposal. The CA, which is a companion analysis to the PA, was designed to provide more confidence that SRS's disposal operations are controlled such that even unrelated sources of contamination that may interact with ongoing disposal operations are taken into account as limits for operations are set. As a result of the briefings on the CA, the CAB became confident with the CA and PA, and endorsed these tools as a sufficient technical basis for LLW disposal.

The foundation for educating the public concerning the technical underpinning for LLW disposal had been established. To ensure that EPA and SCDHEC understood the technical and regulatory details under which LLW was disposed, both organizations were provided with copies of the PA and CA, and were fully briefed as well. Even though EPA and SCDHEC are not the formal regulatory agencies for DOE LLW disposal, it was deemed extremely important to gain their understanding and to provide answers to their questions.

System Analysis & Plan

During the mid 1990s, SRS began a systems engineering analysis (the *System Plan*) for all SRS waste streams including LLW. Based on a detailed set of criteria, the system analysis determined the preferred path for treatment and disposal of each waste stream. It also provided a comparative lifecycle cost analysis that contributed to the selection of the preferred path.

After successfully receiving CAB endorsement of the technical basis for LLW disposal, the process of educating the CAB on the *System Plan* began. In subsequent briefings in 1998 and 1999, the CAB was provided with information as to how the *System Plan* provides a well planned analysis of the proper path forward for each type of waste by setting technical, regulatory, environmental, stakeholder acceptance, and cost criteria to rank each alternative. Using a transuranic waste stream as an example, a presentation was provided to the CAB in April 1999. The CAB indicated its understanding of the approach, and in July 1999, strongly endorsed the systems engineering effort by submitting a formal recommendation to DOE that was specifically related to LLW waste streams. Citizens Advisory Board Recommendation No. 94 stated, "The System Plan approach of using scientific/technical criteria and systems engineering is an excellent way to analyze options for treatment, storage, and disposal of LLW."

A public understanding of SRS's program was now created and stakeholders were ensured that LLW disposal was technically based and protective of the environment.

Vault vs. Trench

The program had now reached a critical juncture. The stakeholders were well informed and had confidence in the basis for the disposal actions and how changes would be made.

The *System Plan,* coupled with an analysis of the disposed waste and the waste forecast, showed that several waste types were low enough in radionuclides to meet the PA limits for trench disposal even though they had been slated for vault disposal. It was determined that if the waste currently scheduled for vault disposal but met the trench disposal limits were to be disposed in the trench, the vault would not be filled to capacity for an additional nine to ten years. This action, of course, would avoid a significant capital expenditure projected for the Fiscal Year (FY) 2009 budget to construct a new vault.

To gain approval to make this change in LLW disposal, the DOE and WSRC management were briefed and agreement obtained that the program was technically and economically sound. At that point DOE-HQ management was briefed and approval to proceed obtained. However, before proceeding with the program SRS wanted to obtain stakeholder endorsement.

SRS briefed the CAB in 1999, explaining in simple (but hopefully elegant) terms the analysis that demonstrated the most cost-effective and environmentally acceptable alternative for LLW that met the trench disposal limits derived from the PA was to dispose of this waste in the trench. Coupled with this line of reasoning was the fact that more robust vault space should be reserved for waste with higher levels of radioactivity.

It was shown that the vault was being filled with bulk volume of waste; however, the curie inventory limit was not being challenged. At that time, 67 percent of the vault volume had been filled, but only 37 percent of the curie inventory limit was being used. Therefore, if waste that met the trench limits was disposed in the trench instead of the vault, the vault would not be filled for ten to fourteen years beyond current projections, thus avoiding a significant capital expenditure.

The CAB passed Recommendation #94 on July 27, 1999 that concurred with the use of the trenches for disposal of LLW meeting the trench waste acceptance criteria. This was truly a "win-win" situation for SRS and its stakeholders. DOE was now able to continue with DOE's critical post cold war missions properly managing its radioactive waste in the most cost-effective manner. Based on a forecast of waste to be disposed in the vault that could now be disposed in the trench, the savings will total approximately $63 million over 20 years of operation.

Volume Reduction

To reduce waste volume and save vault space, a supercompactor was obtained from West Valley at no costs (it was to be excessed) and installed in one of the vault cells in 1999. In order to select wastes for compaction, a Sorting and Segregation Facility was constructed and also installed in one of the unused vault cells in 1998.

As SRS continued to explore opportunities for further reduce disposal cost while continuing to protect human health and the environment, the CAB, now quite active and informed about LLW disposal requested that the cost effectiveness of supercompaction of LLW that was destined for trench disposal be evaluated. During the evaluation, lifecycle cost analyses were performed to include not only near-term supercompaction costs, but also costs of subsidence repair, closure caps, and dynamic compaction during closure cap preparation. As a related part of this study (done in 2001) alternatives to the use of B-25 boxes for waste containment are being evaluated. It turned out that the use of B-25 boxes not only were a major cost, but also increased the maintenance and repair costs due to the void space inside of a box resulting in subsidence once the box was breached. The cost of repairing the subsidence of the closure cap is significant.

The decision has been made to only compact waste which is being disposed in the vault and to not compact waste being disposed in the trench (repair of subsidence is more cost effective). The evaluation of an alternative to the use of B-25's continues.

Engineered Trench

Moving LLW that meets the trench Waste Acceptance Criteria (WAC) from vault to trench disposal also allowed SRS to evaluate more effective trench construction and operational techniques. In February 2001, the first phase of the engineered trench was completed. This project excavated approximately 10,000 cubic meters of disposal space, enough for 4,000 B-25 containers in the first of a three-phase project. The engineered trench provides the same environmental protection as smaller slit trenches that were being used for soil, but added features such as drive-in capability for forklifts and trucks, waste container stacking, and improved handling.

Components-in-Grout

SRS has a large volume of legacy waste (large equipment) which is too large for vault disposal and/or would take up too much valuable vault space if the vaults were used. A technique coined "components-in-grout" was developed during 1999 and 2000 allowing large equipment to be disposed in trenches surrounding the large equipment inside and out with grout designed to limit future subsidence and retard the release of radionuclides. The Performance Assessment (PA) was modified to evaluate this technique, and disposal parameters established. Upon approval of the PA, the first component-in-grout was disposed in late 2000. A trailer used years ago to transfer waste solvent from the reprocessing facilities (canyons) to waste storage tanks was characterized to ensure it met the components-in-grout WAC. The disposal operation involved a crane lift of the trailer, placement in the trench, grouting the base, filling the interior of the tank with cement backfill, and then completing the grouting around the body of the trailer. Two more components-in-grout disposals were completed in 2001 (a large cesium source and a waste water tanker used in the spent fuel program). This disposal technique opens the door for the safe, cost-effective, and environmentally sound disposal of large equipment as SRS moves forward to properly dispose of all legacy waste materials at SRS.

Shipping to Nevada Test Site

On July 11, 2001, the first shipment of LLW left SRS for disposal at Nevada Test Site (NTS). This achievement represents the first of a ten-year shipping program to properly dispose of several LLW streams that do not meet disposal criteria at SRS or are more economical to dispose at NTS. The public involvement during the development of this shipping program was vigorous and often.

The Waste Management Programmatic Environmental Impact Statement (WMPEIS) was required to be issued and the Record of Decision (ROD) needed to include SRS as a shipper of LLW to NTS. The CAB, general public, and the State of South Carolina were all very active in commenting on the PEIS and the CAB provided more than one formal recommendation to DOE. In addition, the SRS Waste Management EIS ROD required modification to recognize offsite disposal of LLW once the ROD on the WMPEIS was issued. An Environmental Assessment (EA) was prepared to present analyses of the potential environmental impacts of shipments of LLW to offsite disposal sites and a Finding of No Significant Impact issued. Ultimately, the CAB provided recommendations to DOE that favored shipment of certain wastes to NTS for disposal..

Accounting for Waste Form Properties

Other "problem" LLW streams required innovative solutions. Environmental Restoration Groundwater Treatment facilities and the Effluent Treatment Facility that treats LLW liquid wastes generate resins, sludges, filtercakes, and carbons that are contaminated with Iodine-129. The concentrations of I-129 in some of these wastes were much too high for disposal in SRS vaults or trenches using conventional techniques for analysis. Through a series of innovative evolutions, a program was determined to investigate the abilities of the wastes themselves to retain and retard the release of I-129 from their waste matrix. Then the Performance Assessment was modified to take into account laboratory measurements of these properties of the waste. It took over two years to conduct the experiments, document the results, and perform the PA modeling to allow DOE to approve this new disposal concept.

In 2001, DOE approved the Performance Assessment Special Analysis that takes credit for the ability of the I-129 bearing waste forms to hold I-129 in the waste matrix, thus preventing the I-129 from being leached out to the groundwater. An important parameter used to evaluate how to dispose of the waste is the distribution coefficient, or Kd value, which is a measure of the propensity of a contaminant to leach from the waste form. Taking into account this property (called Kd) of the waste allows Solid Waste to dispose of more of this type low-level waste in E-Area trenches rather than ship it offsite to Nevada Test Site (NTS). Since significant amounts of the I-129 wastes generated in the past were not packaged for shipment to NTS and has exhibited relative high moisture content, the waste would require repackaging to meet the NTS shipping requirement to account for the high moisture content. There is a concern that the legacy high moisture content waste would have the potential to leak moisture during transport, therefore, WSRC recommended to DOE that this waste be disposed on site in the E-Area trenches. This program represents the first time at SRS that waste form properties were taken into account in analysis of performance of the disposal system.

In granting the approval of the Special Analysis, DOE requested that WSRC assure that the legacy waste continues to meet the 1% free liquid requirement contained in the Waste Acceptance Criteria and the DOE Order 435.1 "Radioactive Waste Management." That assurance was provided to DOE and disposal of the non-organic portion of this waste can now begin. The organic based resins, however, are undergoing longevity testing to ensure that the ability to hold and not leach I-129 is maintained over a long period of time. The results of these tests are expected if successful to allow the balance of the organic resin legacy wastes that meets the Waste Acceptance Criteria (WAC) guidelines will be acceptable for disposal. There is additional legacy high moisture content I-129 wastes stored in E-Area that are above the WAC guideline (too high in I-129 content even after taking into account the new Special Analysis limits). Several activities are underway to develop the technology to allow this waste to be disposed on site, and in parallel, activities necessary to repackage this waste for shipment to NTS are being investigated.

Conclusions

As a result of application of technology, knowledge of the geohydraulogy of the disposal site, Performance Assessment modeling capability, application of knowledge of the regulations, and stakeholder acceptance, SRS LLW disposal system has evolved to a more cost effective while environmentally sound program. A suite of disposal concepts are now available tailored to the types of waste forms and methods that have been developed to accommodate new waste forms should they arise.