Mega Saltstone Disposal Units at the Savannah River Site – 15322

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ABSTRACT

The Liquid Waste (LW) System at Savannah River Site (SRS) is a highly integrated operation involving safely storing radioactive liquid waste in underground storage tanks; vitrifying the higher activity waste; and storing the vitrified waste in stainless steel canisters until permanent disposition is provided; and removing, treating, and dispositioning the low-level waste (LLW) fraction in concrete with final disposition being the Saltstone Disposal Units (SDUs) at the SRS Saltstone Disposal Facility (SDF).

Treatment and disposition of salt waste is the critical path to completion of the SRS Liquid Waste (LW) Disposition Program. Successful and timely salt waste removal and disposal is integral to efforts by SRS to proceed with all aspects of tank cleanup and removal from service. The construction and implementation of the first-of-a-kind Mega SDU (MSDU) is underway to provide the most environmentally safe and cost-effective solution for salt processing and long term storage of the LLW at SRS. The MSDU design is a duplicate of the Water Treatment Tanks located in Syracuse, New York. This commercial design, developed by an affiliate of Savannah River Remediation LLC (SRR), was slightly modified to meet the requirements of the nuclear industry. The MSDU is a critical link in salt disposition. In comparison to the current SDU design, approximately 46 meters (150 feet) in diameter and 7 meters (22 feet) tall with a capacity of approximately 11,000 m^3 (3.0 million gallons), the MSDU is 114 meters (375 feet) in diameter and 13 meters (43 feet) tall which will provide a capacity of approximately 121,000 m^3 (32.0 million gallons) to receive the LLW fraction embedded in a grout-like form. The MSDU will provide the taxpayers an estimated $300M in life cycle savings at SRS by reducing the number of SDUs from the estimated 72 smaller vessels to 7 of the new larger vessels. Additionally, based on the reduced number of SDUs, the environmental footprint is significantly reduced as well.

Due to the similarities between the existing SDU design and the MSDU design, efforts to integrate the MSDU into the LW system are minimal. Required infrastructure modifications will consist of tying into the existing grout and drain lines, as well as the installation of new electrical and instrumentation services for the MSDU. Grout flow testing has been successfully completed, with results showing the MSDU will be a safe and cost-effective replacement for the existing SDUs. The MSDU design is complete, Critical Decision (CD)-3 was approved on June 17, 2014, and the first MSDU, Saltstone Disposal Unit #6 (SDU 6), is being constructed in the existing LW SDF operated by SRR as a Capital Line Item project. As an added benefit, once constructed, lessons learned will be available for future MSDUs at SRS and throughout the complex as necessary.

INTRODUCTION

The mission of the Department of Energy (DOE) Environmental Management (EM) Program is to complete the safe cleanup of the environmental legacy brought about from five decades of nuclear weapons development and government-sponsored nuclear energy research. The SDU 6 project was initiated to provide landfill capacity for receipt of Low Activity Treated Waste grout. The need for the new SDUs is driven by the SRS Liquid Waste System Plan accelerated clean-up objectives. SRS is charged with reducing reliance on long-term liquid storage in the underground storage tanks in the Tank Farms.

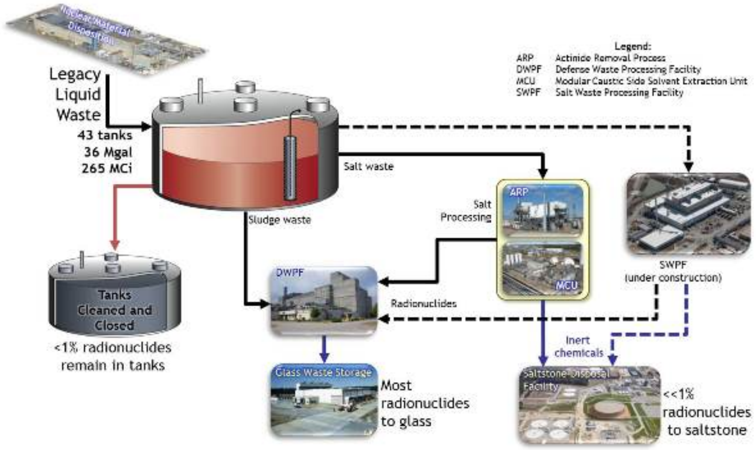

Fig. 1. SRS Liquid Waste System

Built in the 1980s, the Z-Area Saltstone Facility applies a process that immobilizes low level radioactive salt solution waste in grout. Dry materials are unloaded from dry bulk pneumatic trailers and conveyed to storage silos. The dry solids (fly ash, slag, and cement), are then discharged from the silos, weighed, and blended to produce a premix dry feed. Decontaminated salt solution (DSS) is received from H-Area Waste Tank 50 through the Inter-area Transfer System and is temporarily held in a process feed tank (feed and bleed process). The premix and salt solution are proportionally measured and fed to a mixer in the 210-Z process room to produce a non-hazardous saltstone grout, which is pumped to the disposal units for permanent disposition. The grout hardens to form saltstone that is a leach-resistant, non-hazardous solid waste form as defined by South Carolina Department of Health and Environmental Control (SCDHEC) regulations. The combination of the monolithic non-hazardous solid saltstone waste form, concrete cell, and closure cap system controls migration of chemical and radioactive constituents to the environment.

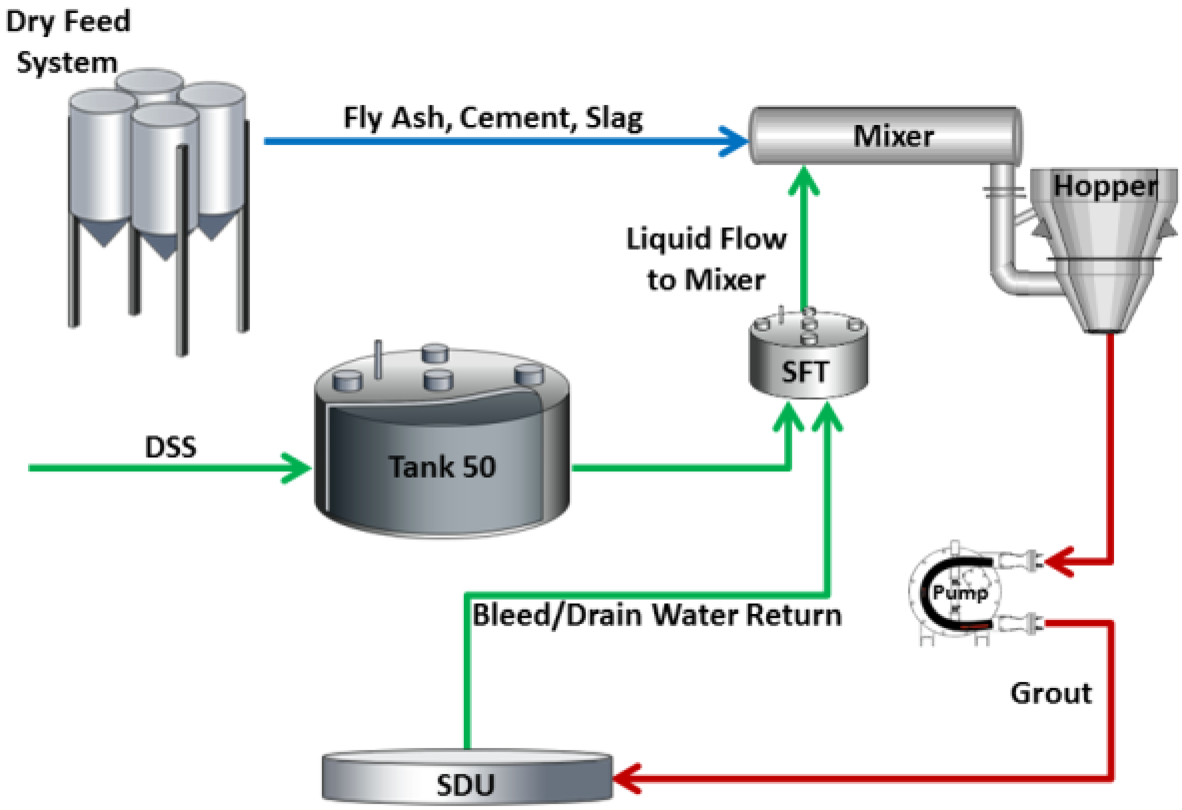

Fig. 2 Saltstone Production Facility Configuration

DESCRIPTION

The SRS Z-Area SDF has been operated by SRR for the DOE since 2009. Z-Area is approximately 238 acres, which currently contains two rectangular SDUs, 1 and 4 (formerly referred to as vaults), and six new circular SDUs. The Saltstone Facility consists of two facility segments, the Saltstone Production Facility (SPF), which receives and treats salt solution to produce solidified Saltstone, and the SDF, which consists of existing SDUs, recently constructed SDUs, and projected SDUs used for the final disposal of the solidified Saltstone. The SPF is permitted as a wastewater treatment facility per SCDHEC Standards for Waste Water Facility Construction. The SDF is permitted as a Class 3 Landfill.

Construction of SDUs 1 and 4 was completed between February 1986 and July 1988. The SPF started radioactive operations in June 1990. Disposal into SDU 1 occurred intermittently from June 1990 to September 1996. Disposal into SDU 4 began in January 1997 and was discontinued in 2012. The rectangular SDUs are divided into sections called cells. Each cell is approximately 30 meters (100 feet) long, 30 meters (100 feet) wide and 8 meters (25 feet) tall. SDU 1 has 6 cells and SDU 4 has 12 cells. After operational filling, the cells will be capped with clean concrete to isolate them from the environment. Final closure of the area will consist of covering the SDUs with engineered closure caps and backfilling with earth.

In March 2003, a Value Engineering Study (VES) was conducted to determine a future SDU construction cost savings effort. Value Engineering (VE) is an organized method for analyzing the functions of systems, equipment, facilities, services and supplies for the purpose of achieving the essential functions at the lowest life cycle cost consistent with required performance, quality, reliability and safety. It is required by Public Law 104-106, Section 4306 (Value Engineering for Federal Agencies), DOE Policy 413.2, Value Engineering, DOE Order 430.1B, Real Property Asset Management, and Office of Management and Budget Circular A-131, Value Engineering.

This VES considered different configurations (cell arrangements) and the use of various construction materials (concrete, mechanically stabilized earth, clay materials, and flexible membrane liners). The study concluded that construction with pre-cast concrete walls/panels is significantly less expensive than cast-in-place concrete. The recommendation of this study was to build a hybrid design which included the use of pre-cast concrete walls, mechanically stabilized earth (reinforced soil), and liners to reduce the construction cost of the future vaults.

In January 2005, another VES was performed. The goal of this study was to determine the best SDU design based on cost, schedule, technical issues, and operational factors for the construction of SDU 2. This study considered several designs as shown below.

TABLE I. Value Engineering Study

Value Engineering Study		
Option	**Type**	**Details**
1	3 Cell Vault	Similar to the Vault 1 rectangular design (prism with sloped roof)
2	Arch Vault	Pre-cast arch building supplied by vendor in the shape of a Quonset hut
3	Cylindrical Vault	American Water Works Association (AWWA) water storage tank
4	Trench Vault	Cast-in-place concrete floor and walls (long walls slope outward) and a pre-cast roof (prixm with sloped walls)
5	Mechanically Stabilized Earth	Recommend hybrid design from previous VES (prism with sloped roof)

Options 2, 4, and 5 were eliminated using a “Go/No-Go” Screening Evaluation. Options 1 and 3 were graded on Cost/Schedule, Technical Issues, and Throughput. Option 3, Cylindrical Vault, scored higher in all three categories and was recommended for the construction of SDU 2. SDU 2 was constructed using this design and since then, SDUs 3 & 5 were constructed using the same design. Each SDU is comprised of two cells approximately 46 meters (150 feet) in diameter and 7 meters (22 feet) high with a capacity of approximately 11,000 m^3 (3.0 million gallons).

DISCUSSION

When planning for SDU 6, another VES was conducted as required by DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets.

The objective of performing a VES is to optimize the project’s economic value by reviewing the project concept and the design of its components/elements to ensure the following:

- Achieve the essential functions of the project,
- Reduce total life cycle cost,
- Attain the required performance, safety, reliability, and quality,
- Sustain the development of an approved schedule, and
- Identify improved ways of doing the same job

For SDU 6, various tank sizes were evaluated for relevant cost comparison features and various tank types were also comparatively estimated for consideration of the cost for the differing construction techniques and configuration of rebar, concrete, internal shell (or not), pre-cast, cast-in-place, etc.

TABLE II. Alternate Design Cost Comparison

Alternate Design Cost Comparison *(based on unit volume cost)*

Alternate Design		Project Cost Savings[a] $K	Life Cycle Cost Savings[a] $K	Project Schedule Savings
1A	Increased Diameter Single Tank (91 m diameter, 6 m high)	5,110	89,000	12 weeks
1B	Increased Diameter and Height Single Tank (91 m diameter, 8 m high)	7,429	130,000	8.5 weeks
1C	Increased Diameter and Height Single Tank (91 m diameter, 10 m high)	6,378	112,000	(15-34 weeks)
1D	Increased Diameter and Height Two Tanks (61 m diameter, 10 m high)	3,786	66,000	(4-7 weeks)

After this initial pass, it became evident that the highest potential cost savings are achieved by taking advantage of economies of scale by using a single large cell instead of the four cell arrangement currently used by SDU 3 & 5.

With the focus now on a single tank, a cost comparison with differing diameters and wall heights was conducted to find the optimal dimensions based on price per liter.

TABLE III. Tank Dimension Comparison

DOE Tank Model Comparison

All tank sizes are based on the DYK Westcott design cast-in-place concrete construction

Log #	Diameter (m)	Height (m)	Columns	Total Volume m^3	Target Cost ($M)	Cost/m^3 ($)
L12-01-01-A	94.5	19.2	142	133,300	26.4	198
L12-01-01-B	103.0	16.2	169	133,800	25.1	188
L12-01-01-C	114.3	13.1	208	133,600	24.7	185
L12-01-01-D	130.5	10.1	271	133,700	27.8	208
L12-01-01-E	156.4	6.7	389	133,700	31.5	236

In this comparison, consideration of funding, proven design, and construction time/schedule were used to bound the analysis. The tank dimensions also considered site specific limitations including grout pump discharge head, the installation of the engineered closure cap in accordance with the Performance Assessment, and soil bearing pressure.

With these constraints, the basis selection came from the current Westcott Reservoir design in Syracuse, New York. The Westcott Tank is similar in volume to what the VES analysis determined to be the most cost effective. The Westcott Reservoir, an AWWA D110 Type I tank, is a post-tensioned steel, reinforced concrete tank. It has been in operation for many years with a proven record of water tightness and structural integrity.

Fig. 3. Wescott Reservoir, Syracuse N.Y.

Since the VES demonstrated that significant cost savings could be achieved on a cost per unit volume basis by constructing the MSDU, a change in the project's technical baseline was needed to pursue this new preferred alternative. To justify this change, SRR developed a conceptual design for the MSDU along with a cost and schedule estimate that was completed in April of 2012. After DOE review, a formal request was made to the EM Acquisition Executive (EM-1) to change the acquisition strategy from the smaller SDUs to the 121,000 m^3 (32 million gallon) MSDU. Approval was granted on June 22, 2012.

The procurement strategy for SDU 6 is a Design, Bid, Build approach, where SRR completed tank design to address the seismic requirements of a Hazard Category 2 DOE facility and then entered the competitive market to receive proposals from general contractors to execute the tank build phase.

On July 17, 2013, the construction of the SDU 6 Mega tank was awarded to Brady and Associates in partnership with DN Tanks. Construction began in October 2013, commencing with the installation of the bottom mud mat. Since the SDF is regulated by SCDHEC as a landfill, a leak detection system has been installed consisting of a high density polyethylene liner inserted between the upper and lower mud mats sloped to four sumps that will be monitored during the operational phase of the disposal cell.

Construction of the foundation started in April 2014 and was completed in September 2014. The first wall section was placed in August 2014 and, as of this writing, 32% of the core walls, 42% of the column footers, and 31% of the total columns have been placed. Roof panels are under construction, as well.

Fig. 4. SDU 6 Under Construction

The project is on track to start work to connect the disposal cell with the SPF during the 3rd quarter of 2015. This work scope, called the Balance of Plant (BOP), includes all structures, systems and components needed to operate with the SPF. This work scope includes:

- Remote cameras and lighting to allow viewing of the grout discharging into the SDU and grout height level indication inside the SDU,
- Ventilation system(s),
- Electrical power connections and skids, Instrumentation and Control signal connections and skids, area lighting, and drainage,

- Installation of a groundwater well(s) to allow hydrostatic testing of the SDU and future SDUs,
- Tie-ins to existing grout transfer and drain water return systems,
- Grout temperature monitoring system,
- Portable vapor space composite, lower flammability limit monitoring equipment and sampling lines,
- Grout distribution system, and
- A drain water system to collect and return the drain water (flush water collected from periodic grout line flushing operations and routine bleed water collected from the grout curing process) back to the SFT. (Fig. 2)

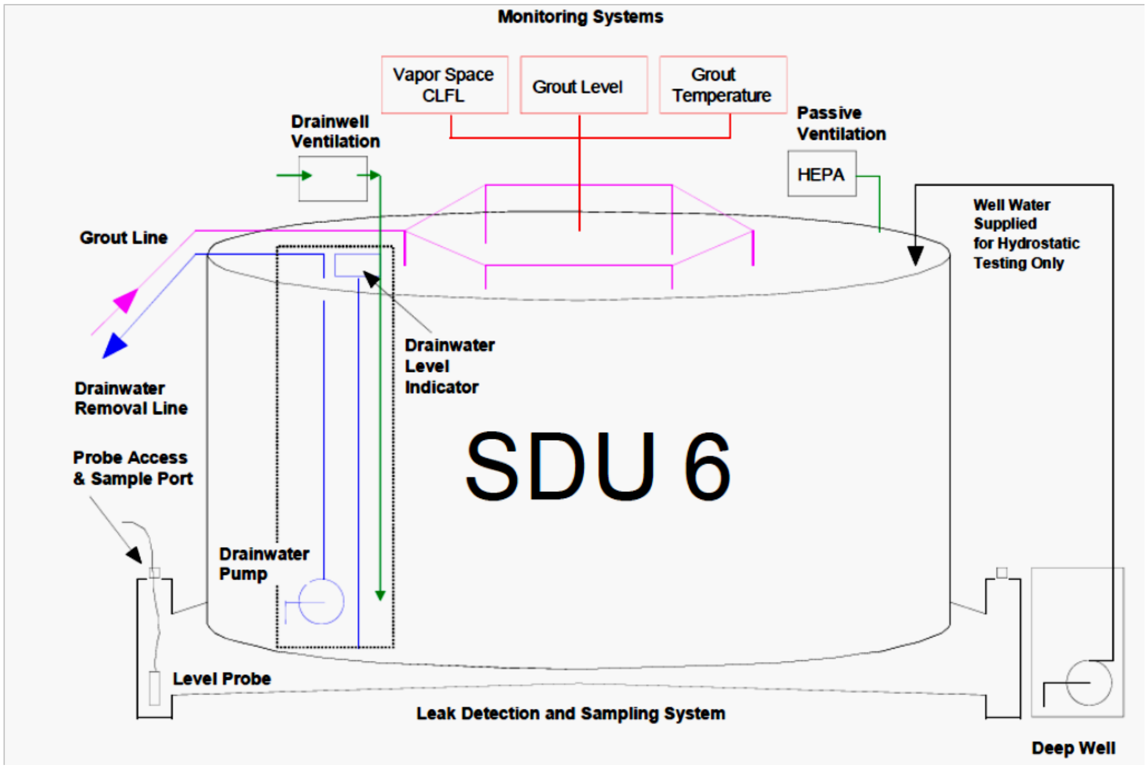

Fig. 5. BOP Configuration

The project is estimated to be complete in the 3rd quarter of 2017. Before start of operations, the disposal cell will be filled with water mixed with a florescent dye. The dye is used to provide evidence if the tank has any leak sites before operation. If dye is detected, the tank is drained, as necessary, repairs made, and re-filled with water treated dye to confirm successful repair.

CONCLUSIONS

It is conservatively estimated that using the MSDU will save DOE approximately $300 million dollars over the life cycle of the SDF. In an era of tight budgets, the savings generated from implementing the MSDU design for LLW disposal will enable SRS to accelerate the closure of liquid waste tanks, and therefore, reduce risk to the State of South Carolina.