Integrated Salt Waste Processing at the Savannah River Site – 15301

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ABSTRACT

Treatment and disposition of salt waste is the critical path to completion of the Savannah River Site Liquid Waste (LW) Disposition and Cleanup Program. The new Salt Waste Processing Facility (SWPF) is a critical link in the pre-treatment chain and will process high curie salt waste removed from various SRS liquid waste storage tanks. Significant infrastructure modifications are needed in the existing LW facilities in order to integrate the SWPF into the LW system.

INTRODUCTION

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; removing, treating, and dispositioning the low-level waste (LLW) fraction in concrete; vitrifying the high level waste; and storing the vitrified waste in stainless steel canisters on site until permanent disposition is available.

SWPF will remove strontium (Sr), actinides, and cesium (Cs), so the resulting decontaminated salt solution (DSS) can be sent to the Saltstone Facility for disposal as LLW. The concentrated Sr, Cs, and other actinides are sent to the Defense Waste Processing Facility (DWPF) for vitrification.

Salt Disposition Integration (SDI) is a portfolio of Operational Activities implementing the necessary facility modifications including:

- Effluent Treatment Facility – New 35,000 gallon (133 m^3) tank; completed and in service since 2011
- Saltstone Processing Facility - adds two new 60,000 (227 $m^{3)}$ gallon tanks for DSS storage
- H-Tank Farm Blend & Feed Tank – modifies two existing one million gallon waste tanks and transfer infrastructure to support SWPF feed staging, blending, and transfer to SWPF
- DWPF – adds new nitrogen purge tank, piping, interlocks, valves, and monitoring and control instrumentation to receive the concentrated Cs and Sr/actinides streams from SWPF
- Transfer Lines - provides tie-in of four transfer lines provided by the SWPF Project, transfer line modifications to Saltstone and DWPF facilities, and distributed control system modifications to align the existing LW facilities with SWPF

In addition to the SDI portfolio, SRR provides DOE with Design Authority and Construction oversight support as well as coordination of site services to ensure full integration of SWPF with existing LW facilities during SWPF construction, commissioning, and first year of operation.

BACKGROUND

The mission of the Savannah River Site (SRS) Tank Farms is to receive, store, transfer, and manage high-level radioactive liquid waste generated at SRS. The large underground storage tanks and associated equipment, known as the 'tank farms', include a complex interconnected transfer system which includes underground transfer pipelines and ancillary equipment to direct the flow of waste. The waste in the tanks is present in three forms: supernatant, sludge, and saltcake. The supernatant is an alkaline aqueous mixture, while sludge consists of insoluble solids and entrapped supernatant. The saltcake results from the evaporation (water removal) of the supernatant. The tank waste is retrieved and treated as sludge or salt solution. Saltcake is retrieved from the waste tanks by removing the interstitial liquid, dissolving the saltcake with water, and finally retrieving the dissolved salt solution for further processing. The high level (radioactive) fraction (actinides, strontium, and cesium) of the waste is vitrified into a glass waste form, while the low-level waste is immobilized in cementitious grout waste called saltstone. Once the bulk of the waste is retrieved and processed, the tanks are operational closed via chemical cleaning, residual waste heel removal, stabilizing remaining residuals with tailored grout formulations and sealing external penetrations (e.g., cooling coil piping and tank riser openings).

The actinide removal process (ARP) and the Caustic Side Solvent Extraction (CSSX) process are deployed in the ARP/Modular CSSX Unit (MCU), to process salt waste for permanent disposition. Actinide removal from salt waste is accomplished by contacting the salt solution with monosodium titinate, filtering the resulting slurry, transferring the actinide-laden solids to the DWPF for vitrification, and transferring the clarified salt solution to CSSX for cesium removal.

The Salt Waste Processing Facility (SWPF) is a new SRS facility currently under construction that is designed to utilize the same monosodium titanate (MST) treatment and Caustic Side Solvent Extraction (CSSX) technologies to treat salt waste with the resulting waste streams to be disposed of through vitrification at DWPF and by incorporation into grout at the Saltstone Processing Facility (SPF). The SWPF salt processing rates will be considerably higher than the current ARP/MCU process leading to acceleration of waste tank closure and completion of the LW Mission. [1] Figure 1 provides an overview of the Liquid Waste System.

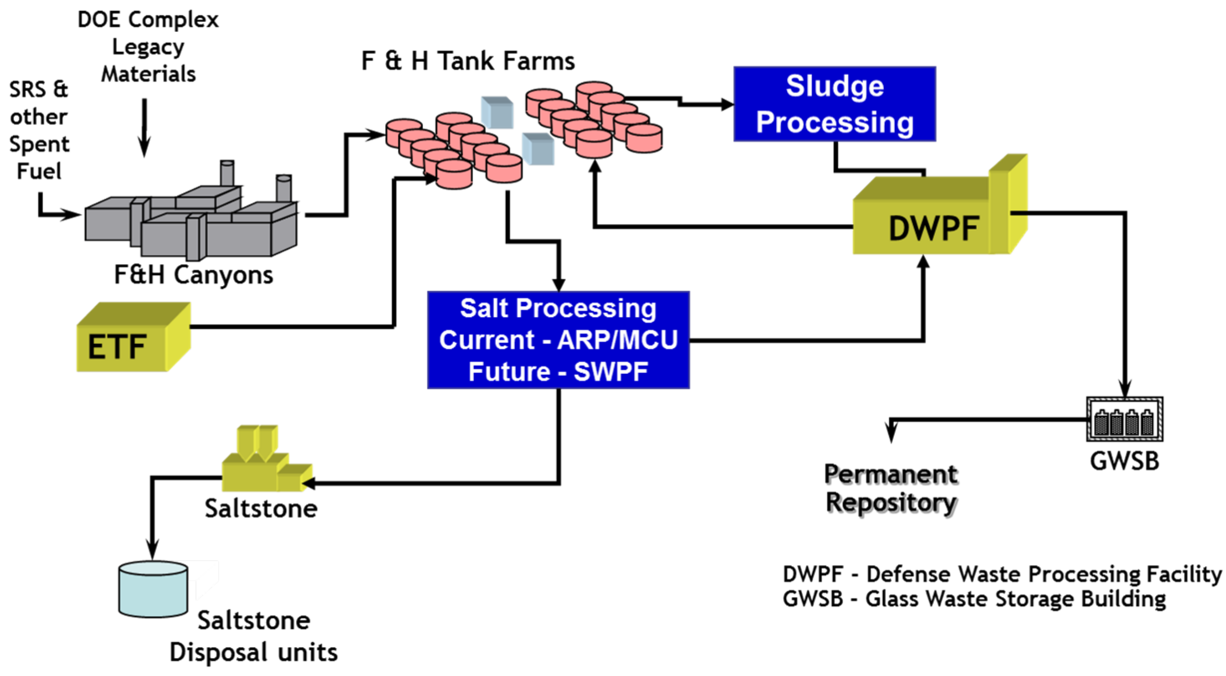

Figure 1. SRS Liquid Waste System Overview

SALT DISPOSITION INTEGRATION PORTFOLIO

A portfolio of projects has been initiated to provide Liquid Waste (LW) physical and programmatic infrastructure to support Salt Waste Processing Facility (SWPF) radioactive operations scheduled to begin by December 2018. Physical modifications are required in the Effluent Treatment Plant, Saltstone Production Facility, H-Area Tank Farm, and the Defense Waste Processing Facility to prepare and stage feed for SWPF and to receive its effluent streams.

Integration of modification implementation across these LW facilities while continuing existing waste processing activities will be keys to the project's success. Integration of salt feed preparation projects, LW system planning, and SDI projects will be necessary to ensure adequate feedstock is qualified and staged to support SWPF startup.

Effluent Treatment Facility

The Effluent Treatment Facility (ETF) located in H-Area receives process waste water for treatment and disposition from various generators across the Savannah River Site (SRS). The process waste water received from evaporators and various other sources is potentially contaminated with small quantities of radionuclides and process chemicals. After ETP processing, waste concentrate containing low level radioactive waste is stored before transfer to Tank 50H.

Tank 50H serves as a collection point and feed storage location for the low level radioactive waste that is acceptable for treatment and processing at the Saltstone Processing Facility (SPF). Previous to these modifications, ETP transferred waste concentrate to Tank 50H every week. With transfers of decontaminated salt solution from SWPF planned to occur daily, the potential existed for transfer sequencing conflicts. A new Waste Concentrate Hold Tank (WCHT) with a nominal 30,000 gallon (114 $m^{3)}$ storage capacity provides operational flexibility for transfers from ETF to Tank 50H or directly to SPF. [2] Figure 2 shows installation of the WCHT. The WCHT provides sufficient storage capacity to reduce ETF transfer frequency to Tank 50H from weekly to quarterly relieving transfer conflicts.

The ETF modification had to coordinate tie-ins of new piping and process vessel ventilation (PVV) to existing, operating facility piping and equipment. Process vessel ventilation was tested in static conditions (for contamination control during startup testing, no transfers into or out of the tank were made during PVV testing) following completion of construction. In subsequent initial radioactive operation, the tank vacuum was challenged during transfers into the tank. Adjustments were made in the control scheme to adequately maintain tank vacuum. This event highlights the importance of adequately addressing transient operating conditions in design and testing. The ETF modification has been in successful radioactive operation since September 2011.

Figure 2. New Waste Concentrate Hold Tank at the Effluent Treatment Facility

Salt Solution Receipt Tanks

This modification provides the infrastructure, facility, and process changes necessary to implement a new operating strategy at the Saltstone Processing Facility (SPF). Two new Salt Solution Receipt Tanks (SSRTs) have been constructed, with a working volume of approximately 60,000 gallons (227 m^3) each, for receipt and processing of decontaminated salt solution (DSS) produced in the near-term by MCU and in the future by SWPF. Additionally, this modification will allow the SPF to handle short duration, unplanned outages that could otherwise delay receipt of routine DSS transfers from Tank 50H during SWPF operation. Figure 3 shows the SSRTs during construction.

The current SPF Salt Feed Tank will be reconfigured to provide additional Saltstone Disposal Unit bleed and flush water storage capacity. The Salt Feed Tank will be connected to the SSRTs and will have the capability to transfer bleed water to the SSRTs for recycling if needed. The SSRTs have full secondary containment enclosures with the ability to return waste to the tanks in the event of a leak. A new standalone process vessel ventilation system will provide contamination control and flammable vapor control.[3]

Concrete enclosure cells surround the SSRTs to provide containment and shielding. Shielding thickness for the western cell is designed to accommodate SWPF DSS with Cesium-137 content of 0.0002 Ci/gal (5.2E-5 Ci/liter). The eastern cell has thicker walls and can accommodate Cesium-137 content up to 0.045 Ci/gal (1.2E-2 Ci/liter).

As was the case with the ETF modifications, the SSRT project faces the challenge of integrating the new modification into an existing, operating facility. Spectacle blind flanges are strategically placed at key process piping interface points to allow for isolation of the new SSRT piping, tanks, and equipment from exiting contaminated piping and equipment. After a brief outage for final piping connections, these isolation points will allow resumption of facility operations until final start-up testing and readiness assessment of the SSRT modification can be completed in a subsequent outage.

Construction completion, start-up testing, and turnover of the SSRT modification is planned for 2015. In the period from turnover until SWPF startup, the SSRTs will be available to receive DSS from the MCU process provided the Cesium-137 levels in the DSS are within the shielding basis. If not, the key piping interface points can remain isolated until SWPF startup.

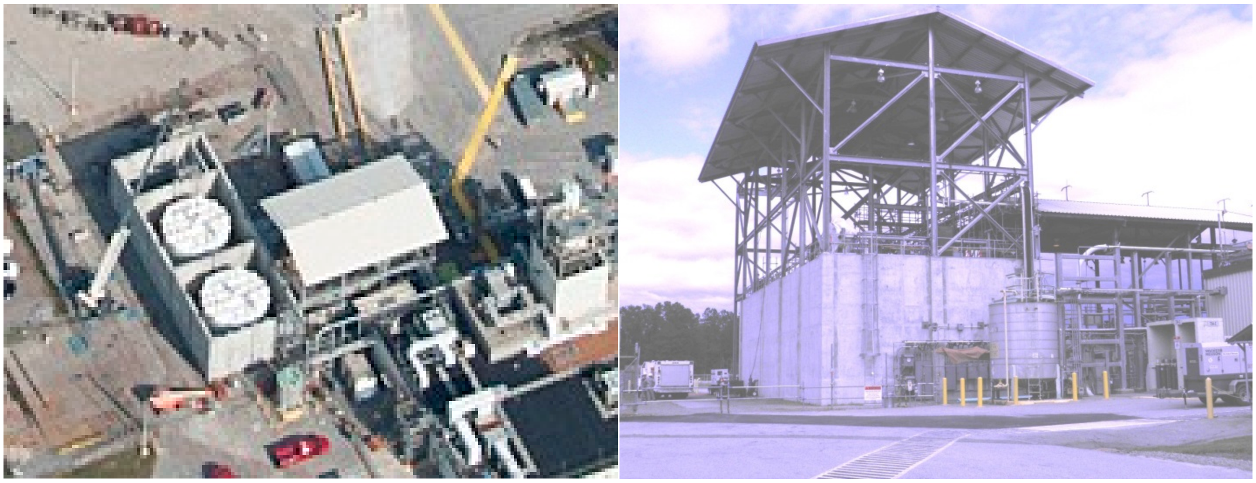

Figure 3. Salt Solution Receipt Tanks

Blend and Feed Tanks

The SDI Blend & Feed (B&F) project will provide one salt solution Blend Tank (existing Waste Tank 21H), and one SWPF Feed Tank (existing Waste Tank 49H) and the applicable inter-tank transfer lines systems. The blending operation is to blend supernatant liquid into a homogenous mixture to meet the SWPF Waste Acceptance Criteria (WAC). H-Tank Farm Operations will perform batch preparation and qualification for a transfer to SWPF of 4.6M gallons of salt waste feed material in the first year and up to 7.2 M gallons (27,255 m^3) per year in subsequent years.

Blending, a new mixing application within the Tank Farms, requires the miscible salt solutions from potentially multiple source tanks per SWPF feed batch to be well mixed without disturbing settled sludge solids that may be present in a Blend Tank. To develop the necessary technical basis for the design and operation of blending equipment, scaled blending and transfer pump tests and Computational Fluid Dynamics (CFD) modeling were conducted. An eight foot diameter pilot-scale blending tank, including tank internals such as the blending pump, transfer pump, removable cooling coils, and center column, were used. Blending tests determined that pump should be angled upward 15º from horizontal and oriented parallel to the tank wall with the discharge located approximately mid-height of the tank level to prevent solids disturbance for a very thin, conservative, sludge simulant. Experimental results were compared to CFD results and available engineering literature to validate CFD modeling. [4,5,6] Experimental equipment arrangement is shown in Figure 4.

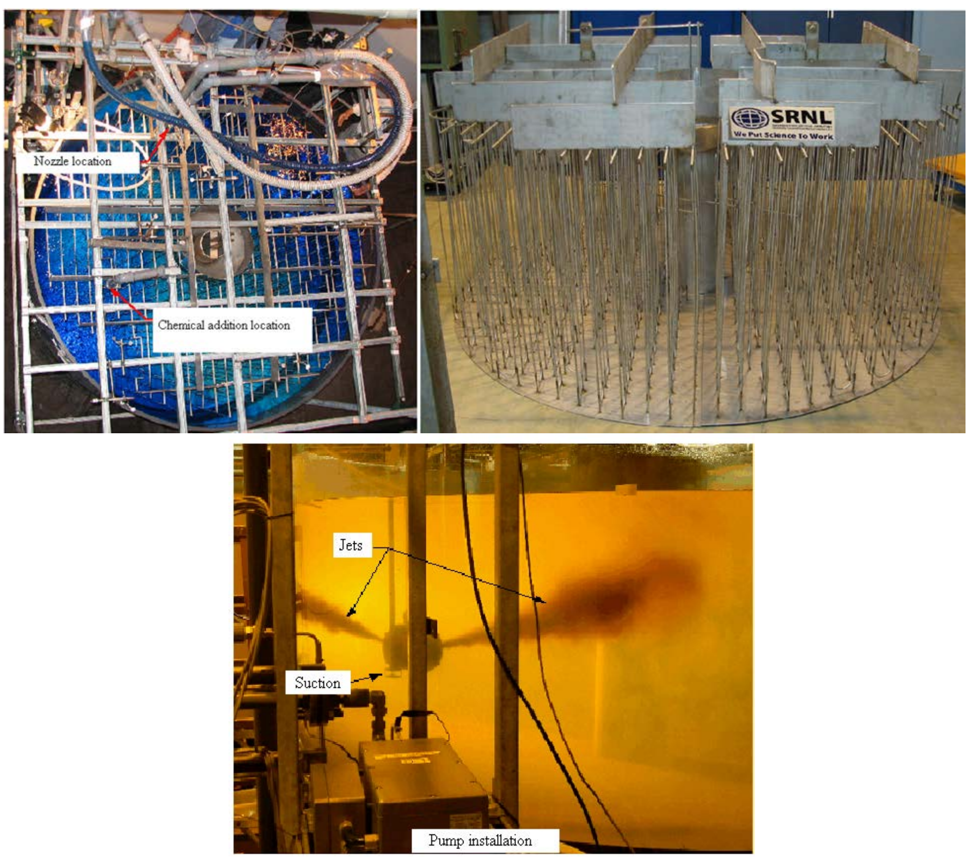

Figure 4. Submersible Blender Pump – Laboratory 1/10th Scale Testing

New submersible transfer pumps were also designed and fabricated to allow transfer of blended salt solutions without entraining and transferring forward any settled solids which could challenge allowable solids in SWPF feed.

SDI Blend Tank modifications will include design, construction, startup testing, and facility support to prepare Tank 21H to be used as a Blend Tank. This tank already has operable mixing pumps and minimal settled solids. Therefore, the existing pumps will be used for blending with a subsequent settling period to minimize any suspended solids in the blended salt solution. Due to the expected radioactivity levels in the blended SWPF feed, additional shielding will be installed around the tank's transfer pump.

SDI Feed Tank modifications will include design, construction, startup testing, and facility support to prepare Tank 49H to be utilized as an SWPF Feed Tank. Tank 49H currently serves as the feed tank for the nearby ARP/MCU process. The existing transfer pump will be replaced with a new submersible transfer pump sized to create the pressure necessary to transfer waste the longer distance to SWPF. The higher discharge pressure from the new transfer pump requires new transfer piping to be installed for portion of the transfer path to SWPF. The existing transfer line into the tank will be modified to provide an incoming blended feed transfer discharge point high in the tank to avoid disturbing any settled solids. [7] See Tank 49H in Figure 5.

Figure 5. Tank 49H – Future Feed Tank for SWPF

DWPF Modifications

The DWPF Modifications scope under the Salt Disposition Integration portfolio will modify existing infrastructure and facilities to receive high activity effluent streams from the Salt Waste Processing Facility. The existing Low Point Pump Pit (LPPP) facility will be a hub for transfers between H-Tank Farm to SWPF and from SWPF to DWPF. As its name implies, the LPPP is physically at the lowest elevation for transfers between SWPF and LW facilities. Transfer piping into the LPPP will be modified to create connections to LPPP process vessels allowing draining of the transfer piping when needed.

Qualified salt solution feed for SWPF will be transferred from Tank 49H through both existing and new underground transfer piping and will pass through the LPPP Recycle Cell, with drain connection to the Recycle Pump Tank, before being received in SWPF. The Monosodium Titanate (MST)/Sludge stream from SWPF will be received in the LPPP Precipitate Pump Tank (PPT) prior to transfer to DWPF. The Strip Effluent stream from SWPF will pass through the PPT cell, with drain connection to the PPT vessel, prior to being received in the Strip Effluent Feed Tank in DWPF. Due to the new stream transfer paths through the LPPP cells, cell sump pumps and piping will be added.

Both the MST/Sludge and Strip Effluent streams may contain residual organic extraction solvent from SWPF processing which in turn presents a flammability potential for the LPPP cells and vessels. The DWPF Modifications project scope includes new temperature interlock and instrumentation to monitor LPPP PPT vessel temperature, and to shut off mechanical heat generation sources (e.g., transfer pump, agitator) upon high temperature. Controls and instrumentation will be provided to stop the LPPP-PPT transfer pump on low agitator power. [8]

Several DWPF process vessels already have nitrogen purges of their vapor spaces to preclude formation of flammable conditions. The SWPF MST/Sludge and Strip Effluent streams create potential for new flammability concerns in some DWPF process vessels. To support the new vessel purges, an additional nitrogen storage tank and protective missile shielding was completed in February 2013. Figure 6 shows installation of the new nitrogen storage tank.

Figure 6. New Nitrogen Storage Tank at DWPF

East and West Transfer Line Tie-ins

The Salt Disposition Integration East and West Transfer Line Tie-Ins project will provide new underground transfer piping connections between new SWPF transfer lines and existing LW piping.

The East Transfer Line tie-in will provide a route for transferring Decontaminated Salt Solution (DSS) from SWPF to Tank 50H in the H-area Tank Farm (HTF). New DSS transfer piping was installed by SWPF in 2013 to a designated tie-in point near the existing H-Area to Saltstone Inter-Area Transfer Line (IAL). New piping will be installed by LW to connect the new SWPF Project DSS transfer line to the IAL. This piping connection presents the unique challenge of draining and flushing the IAL prior to making the tie-in. [9]

The West Transfer Line tie-ins will install piping to connect new MST/Sludge, Strip Effluent, and salt solution feed piping from SWPF to existing LW piping near the LPPP. Figure 7 shows installation of the SWPF piping to the designated tie-in point near the LPPP. Installation of the SWPF Project piping was completed in July 2014.[10]

Figure 7. Installation of West Transfer Lines

This project also establishes the LW Distributed Control System modifications to facilitate transfers between H-Tank Farm, SWPF, and DWPF. Both hardware and software modifications will create DCS alarms, interlocks, and permissive signals to enable waste transfers between LW and SWPF. Integrated startup testing, operating procedure development, and operator training will be needed to demonstrate transfer proficiency between affected facilities.

SWPF INTEGRATION SUPPORT

In addition to the physical LW infrastructure modifications defined in the SDI Portfolio, SRR provides coordination and integration management services to the SWPF DOE Project Office. Key interfaces for services such as utilities, domestic and fire water supplies, and radioactive and hazardous waste management are defined through Interface Control Documents (ICDs), approved jointly by DOE, SRR and Parsons, the Engineering, Procurement, and Construction contractor for SWPF. ICDs also address technical process interfaces including waste transfer controls and waste acceptance criteria development. A total of 27 ICDs were established. [11]

Identifying key interface activities and managing those activities through a project schedule are essential to minimizing interface issues that could impact SWPF startup. In 2014, SRR provided a detailed schedule of approximately 6,000 LW activities needed to support SWPF startup and first year of operation. A new Integrated Project Team (IPT) with participation from DOE, SRR and Parsons was chartered in October 2014 to oversee integration of the SRR schedule with the Parsons SWPF schedule, to monitor schedule execution, and to manage timely identification and resolution of issues that could impact SWPF startup.

CONCLUSIONS

The scope to prepare for the startup and operation of SWPF spans many of the existing LW operating facilities. Significant physical infrastructure modifications are needed to create the necessary waste transfer paths and processing capability. A portfolio of projects known as Salt Disposition Integration will design, install, and test those modifications to ensure LW readiness prior to the SWPF ORR.

Detailed execution schedules are developed for each SDI project that show completion of the LW integration scope prior to the projected startup of SWPF. Other interface support is defined and managed through the ICD process utilizing close coordination between DOE, SRR and Parsons. A new IPT focused on integrating SWPF and SRR activities as appropriate will provide additional management oversight to key activities and help ensure early identification and resolution of interface issues.

Accelerated salt waste processing is critical to the overall LW mission. Through continued emphasis on efficient project execution and integration management; SRR is well on track to support the projected 2018 startup of SWPF.

REFERENCES

1. D.P. Chew and B.A. Hamm, “Liquid Waste System Plan”, SRR-LWP-2008-00001, Revision 19, May 2014
2. R.J. Gray, “Task Requirements and Criteria Tank 50H Return to Service – ETP Scope”, G-TC-H-00048, Revision 6, August 8, 2011
3. J. Medlin, “Task Requirements and Criteria Salt Solution Receipt Tanks – Saltstone Facility Modifications”, U-TC-Z-00001, Revision 10, April 22, 2014
4. R.A. Leishear, M.D. Fowley, and M.R. Poirier, “SDI, Blend and Feed Blending Pump Design, Phase 1”, Savannah River National Laboratory, SRNL-STI-2010-00054, Revision 0, June 2010.
5. R.A. Leishear, M.D. Fowley, and M.R. Poirier, “Blending Study for SRR Salt Disposition Integration: Tank 50H Scale-Modeling and Computer-Modeling for Blending Pump Design, Phase 2 (U)”, Savannah River National Laboratory, SRNL-STI-2010-00151, May 2011.
6. R.A. Leishear, M.R. Poirier, and S.Y. Lee, “Tank 21 and Tank 24 Blend and Feed Study: Blending Times, Settling Times, and Transfers”, Savannah River National Laboratory, SRNL-STI-2012-00306, May 2012.
7. R.J. Gray, “Task Requirements and Criteria SDI Blend and Feed Project”, M-TC-H-00071, Revision 10, September 6, 2012.
8. R.M. Hoeppel, “Task Requirements and Criteria DWPF Modifications for Salt Disposition Integration”, G-TC-S-00003, Revision 3, August 16, 2010.
9. R.J. Gray, “Task Requirements and Criteria Tank 50H Return to Service – East Transfer Line Scope”, G-TC-H-00049, Revision 1, April 2, 2009.
10. R.M. Hoeppel, “Task Requirements and Criteria West Transfer Line Modifications for Salt Waste Processing Facility Tie-in to DWPF”, G-TC-S-00004, Revision 2, November 8, 2012.
11. “Interface Control Document List”, V-ESR-J-00001, Revision 1, May 25, 2010.