September 30, 2013

MEMORANDUM TO: Gregory Suber, Chief
Low-Level Waste Branch
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
and Environmental Protection

THRU: Christepher McKenney, Chief **/RA/**
Performance Assessment Branch
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
and Environmental Protection

FROM: Cynthia S. Barr, Sr. Systems Performance Analyst **/RA/**
Performance Assessment Branch
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
and Environmental Protection

SUBJECT: TECHNICAL REVIEW OF FINAL INVENTORY DOCUMENTATION FOR TANKS 5 AND 6 AT F-TANK FARM, SAVANNAH RIVER SITE, (PROJECT NO. PROJ0734)

The United States Nuclear Regulatory Commission (NRC) staff has performed a technical review of several documents prepared by the United States Department of Energy (DOE) that detail development of the final inventory for Tanks 5 and 6 at the F-Tank Farm, Savannah River Site, South Carolina. This technical review supports Monitoring Factor 1.2 "Residual Waste Sampling" and Monitoring Factor 1.3 "Residual Waste Volume", as detailed in NRC staff's plan for monitoring the F-Tank Farm (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12212A192).

As a result of review of several DOE documents related to the development of the Tank 5 and Tank 6 final inventories, NRC staff concludes that DOE has made several improvements to its tank sampling and volume estimation programs. A sampling and analysis program plan was developed, which generally provides a technically sound approach to developing tank inventories in the future. Training and procedures have also been developed to help formalize the tank residual volume mapping program. All of these improvements have led to a more technically defensible program. NRC staff has listed several technical concerns related to Monitoring Factors 1.2 and 1.3 and therefore, these Monitoring Factors will remain open at this

CONTACT: Cynthia Barr, FSME/DWMEP
(301) 415-4015

time. NRC staff will monitor progress on these technical concerns as tank farm closure progresses. When NRC staff determines that the technical concerns have been addressed, NRC staff may decide to close these Monitoring Factors. If Monitoring Factors 1.2 and 1.3 are closed before development of final inventories for all F-Tank Farm tanks, NRC staff will perform a more cursory review of final inventory development under Monitoring Factor 1.1 “Final Inventory and Risk Estimates”.

Enclosure:
Technical Review of Final Inventory
Documentation for Tanks 5 and 6

time. NRC staff will monitor progress on these technical concerns as tank farm closure progresses. When NRC staff determines that the technical concerns have been addressed, NRC staff may decide to close these Monitoring Factors. If Monitoring Factors 1.2 and 1.3 are closed before development of final inventories for all F-Tank Farm tanks, NRC staff will perform a more cursory review of final inventory development under Monitoring Factor 1.1 “Final Inventory and Risk Estimates”.

Enclosure:
Technical Review of Final Inventory
Documentation for Tanks 5 and 6

DISTRIBUTION (w/ enclosure): CGrossman LParks GAlexander MFuhrmann
OPensado, CNWRA WIR Service List DOE SRS Email List

ML13085A291

OFC	DWMEP	DWMEP	DWMEP	DWMEP	DWMEP
NAME	CBarr	TMoon	HFelsher	CMcKenney	CBarr
DATE	8/20/13	8/22/13	8/29/13	9/30/13	9/30/13

OFFICIAL RECORD COPY

Technical Review of Final Inventory Documentation Supporting
F-Area Farm, Tanks 5 and 6 Closure

Date: September 25, 2013

Reviewers:

Cynthia Barr, Senior Systems Performance Analyst, NRC
Osvaldo Pensado, Group Manager, Center for Nuclear Waste Regulatory Analyses
Leah Parks, Systems Performance Analyst, NRC

<u>Primary Documents:</u>

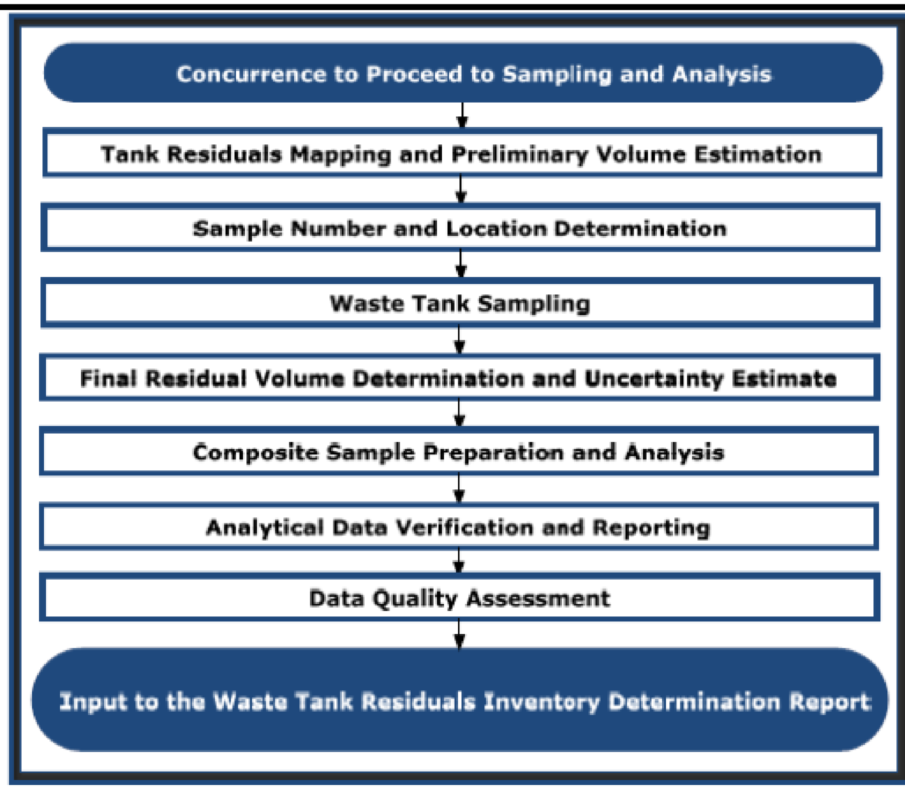
1. SRR-CWDA-2011-00050, Revision 1, "Liquid Waste Tank Residuals Sampling and Analysis Program Plan", Savannah River Remediation, LLC, Closure and Waste Disposal Authority, Aiken, SC, February 2012.
2. SRR-CWDA-2011-00117, Revision 0, "Liquid Waste Tank Residuals Sampling—Quality Assurance Program Plan", Savannah River Remediation, LLC, Closure and Waste Disposal Authority, Aiken, SC, February (2012).SRR-CWDA-2012-00027, Revision 1, "Tank 5 Inventory Determination", August 2012.
3. U-ESR-F-00048, Revision 0, J.L., Clark, "Tank 5 Final Volume Determination and Uncertainty Estimate Report", DOE Savannah River Site, Aiken, SC, Rev. 0, April (2011).
4. SRR-LWE-2010-00285, Revision 1, "Tank 5 Sampling and Analysis Plan", Liquid Waste Operations Closure Project Engineering, November (2010).
5. SRR-LWE-2010-00340, Revision 0, "Addendum to Tank 5 Sampling and Analysis Plan", Liquid Waste Operations, Closure Project Engineering, December (2010).
6. SRNL-STI-2012-00034, Revision 1, L. N. Oji, D. Diprete, C. J. Coleman and M. S. Hay, "Analysis of the Tank 5F Final Characterization Samples—2011 (U)", August (2012).
7. SRR-CWDA-2012-00075, Revision 0, "Tank 6 Inventory Determination", Savannah River Remediation, LLC, Closure and Waste Disposal Authority, Aiken, SC, August (2012).
8. SRR-LWE-2011-00245, Revision 2, J.L., Clark, "Tank 6 Final Volume Determination and Uncertainty Estimate", Interoffice Memorandum, Savannah River Remediation, Savannah River Site, Aiken, SC, June (2012).
9. SRR-LWE-2010-00300, Revision 1, "Tank 6 Sampling and Analysis Plan", Liquid Waste Operations, Closure Project Engineering, January (2011).
10. SRR-LWE-2011-00209, "Tank 6 Sampling and Analysis Plan Addendum", Liquid Waste Operations, Closure Project Engineering, August (2011).
11. SRR-LWE-2011-00235, Revision 0, "Tank 6 Sampling and Analysis Plan Addendum 2", Liquid Waste Operations, Closure Project Engineering, October (2011).
12. SRNL-STI-2012-00365, Revision 0, L. N. Oji, D. P. Diprete, C. J. Coleman, M. S. Hay and E. P. Shine, "Analysis of the Tank 6F Final Characterization Samples-2012 (U)", Savannah River National Laboratory, Savannah River Nuclear Solutions, LLC, Aiken, SC, June (2012).

Enclosure

Summaries of DOE Technical Reports:

SRR-CWDA-2011-00050, Revision 1, "Liquid Waste Tank Residuals Sampling and Analysis Program Plan"

SRR-CWDA-2011-00050, Rev. 1, provides programmatic information related to sampling and analysis of residual waste remaining in SRS tanks following waste retrieval operations. The document provides information regarding the roles and responsibilities of various organizations, and the types of documentation (e.g., plans, reports) that are generated during the process. Figure 1 illustrates the general sampling and analysis process.



Note: Colored ovals are predecessor and successor activities, clear rectangles are activities associated with the LWTRSAPP.[1]

Figure 1 Residual Tank Waste Sampling Approach

The purpose of the sampling program is to obtain data of sufficient quality to develop a final inventory for use in performance assessment calculations or special analyses. There are many obstacles to obtaining adequate samples including access and sampling technology limitations, harsh radiological conditions, internal obstructions, and certain waste characteristics that make it difficult to obtain sufficient sample (e.g., dried and thin waste accumulations). These difficulties must be overcome to obtain a sufficient quantity of sample that is representative of the inventory remaining in the tank.

A stratified random sampling approach is proposed. As a starting point, five samples are collected for compositing. These samples are taken from different areas of the tanks called

[1] LWTRSAPP stands for Liquid Waste Tank Residuals Sampling and Analysis Program Plan

"segments". The segments represent populations within the tank with groupings based on proximity or expected similarity in waste characteristics (e.g., non-uniform, thicker accumulations or mounds remaining in the tank after waste retrieval operations). More than one of the five samples can come from the same segment (i.e., there can be fewer segments than samples with more than one sample taken from a segment). Three composite samples are analyzed with each composite composed of the five samples. The number of samples taken from any particular segment is based on the relative volume of the segment. Additionally, a volume proportional compositing approach is employed in which the volume percentage of each segment determines the percentage of the total composite that comes from that segment (see also SRNL-STI-2011-00323 that provides a statistical assessment of the volumetric proportional compositing method). DOE indicates that the sampling methodology presented in SRR-CWDA-2011-00050, Rev. 1, does not apply to sampling Tanks 5, 6, 18, and 19, although many of the approaches outlined in the document were followed when sampling Tanks 5 and 6. The major difference between sampling conducted for Tanks 5 and 6 and sampling conducted for Tanks 18 and 19 is that discrete samples were taken for Tanks 18 and 19 (i.e., Tank 18 and 19 samples were not composited).

NRC staff requested two secondary references which were provided by DOE via email on April 2, 2013: (1) SRNL-STI-2010-00386, Coleman, C., et al., "Characterization of Additional Tank 18F Samples, Savannah River Site", Aiken, SC, Rev. 0, September 2, 2010, and (2) SRR-CWDA-2011-00117, "Liquid Waste Tank Residuals Sampling-Quality Assurance Program Plan", Savannah River Site, Aiken, SC, Rev. 0, February 2012. SRNL-STI-2010-00386 (page 10) states "good sample homogeneity was demonstrated in Tank 18 by major element determinations of better than 20 percent relative standard deviation for the entire analytical process of sub-sampling the power, shielded cell dissolution, and elemental analysis through Inductively Coupled Plasma-Optical Emission Spectroscopy". Appendix A of SRNL-STI-2010-00386 contains additional information to support the homogeneity conclusion. Appendix B of this document contains information on analytical techniques and detection limits. NRC notes that SRNL-STI-2010-00386 provides support regarding Tank 18 waste homogeneity. However, because of differences in waste streams and cleaning technologies for various tanks, conclusions regarding Tank 18 waste homogeneity do not necessarily apply to Tanks 5 and 6 or other F-Tank Farm tanks. The Quality Assurance Program Plan, SRR-CWDA-2011-00117, is summarized below.

As a result of the review of SRR-CWDA-2011-00050, Revision 1, NRC staff had a number of questions that it posed to DOE during the March 27-28, 2013, onsite observation (see onsite observation report, ML13113A322). Most notably, NRC inquired about the basis for the number of samples per composite (five samples) and the number of composites to be analyzed (three composites). DOE indicated that the waste is expected to be well mixed such that five samples are sufficient to capture variability within the tank. DOE also indicated that three composite samples are needed to get good statistics on composite sample variability. DOE provided in-process volume mapping illustrations during various stages of waste retrieval to demonstrate that the solids are well mixed. DOE stated that it was not asserting that the residual waste is homogeneous, but rather that the waste is well mixed throughout the tank.

<u>SRR-CWDA-2011-00117, Revision 0, "Liquid Waste Tank Residuals Sampling—Quality Assurance Program Plan"</u>

The Liquid Waste Tank Residuals Sampling-Quality Assurance Program Plan was prepared to establish the waste tank sampling and analysis quality program protocols necessary to characterize the residual materials. The characterization data is needed to support waste tank removal-from-service decisions. The quality assurance program plan contains information on roles and responsibilities, including functional organizations and process, analytical methods, analytical operating procedures, collection of samples, chain of custody, and data management. Figure 2 below illustrates the general process and relative timing of sampling-related events.

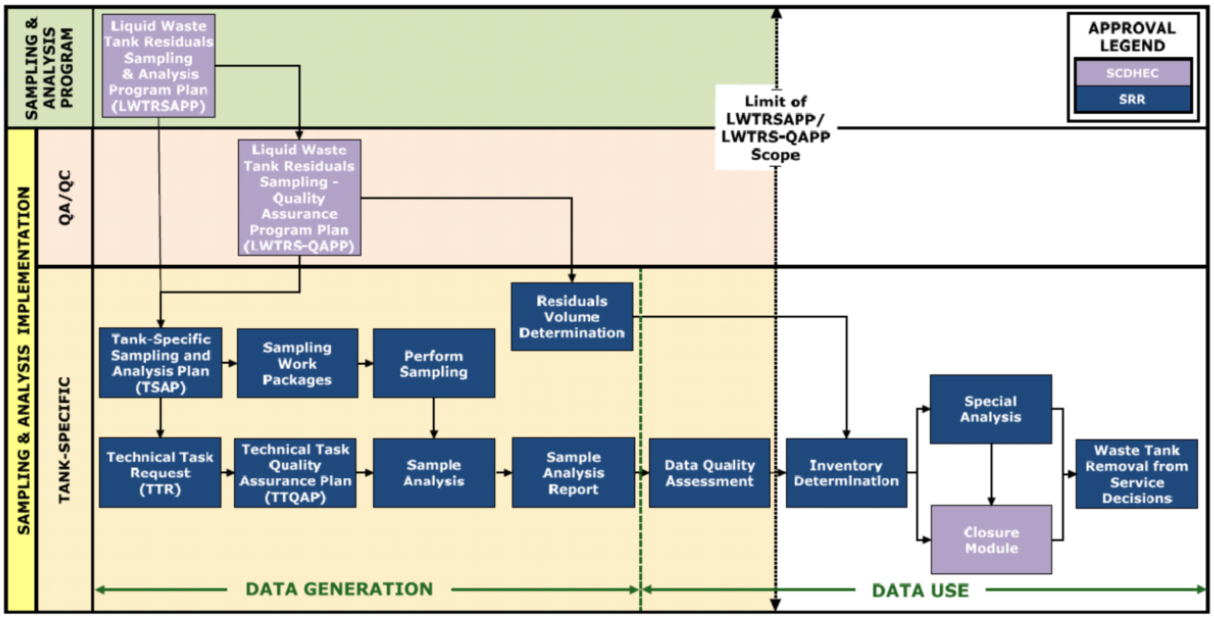


Figure 2 Liquid Waste Tank Residuals Sampling and Analysis Program Process. Image Credit: Figure A6-1 in SRR-CWDA-2011-000117, Rev. 0.

NRC staff discussed the results of its review of SRR-CWDA-2011-000117 during the August 27-28, 2013, onsite observation. NRC staff noted that the Sampling and Analysis, and Quality Assurance Program Plans do not present common terminology for various forms of uncertainty related to sampling and analysis.

<u>SRR-CWDA-2012-00027, Revision 1, “Tank 5 Inventory Determination”, August 2012</u>

SRR-CWDA-2012-00027, Revision 1 summarizes the development of the inventory for Tank 5 and cites several references used to support the inventory development. The sample plan SRR-LWE-2010-00285 provides information on the number and locations of samples. Uncertainty in volume is addressed using a volumetric compositing approach during sampling. This approach was reviewed by statistical experts at Savannah River National Laboratory in SRNL-STI-2011-00323. The sample results are provided in SRNL-STI-2012-00034 and statistically analyzed in SRNL-STI-2011-00613. Density is also measured to allow conversion of volume estimates to mass. A measurement of solids content of the samples is needed to convert the dry weight concentration to a wet weight concentration. DOE estimated that 1900 gallons (7,900 L) of residual waste remained in Tank 5 following waste retrieval (U-ESR-F-00048). DOE also provides an upper and lower estimate of the residual waste volume of 1300 gallons (4,900 L) and 2700 gallons (10,200 L), respectively.

One cooling coil sample was taken from above and one sample from below the oxalic acid liquid level of 45 inches. SRNL normalized cooling coil activity to surface area with results provided in SRNL-STI-2011-00372. DOE calculated the tank wall inventory using cooling coil concentrations. A residual waste volume of 4.7 gallons (18 L) was estimated to be associated with abandoned tank equipment (SRR-LWE-2012-00102). The concentration of the equipment waste was assumed to be the same as the residual floor concentrations. DOE estimates 15 gallons (57 L) of waste remain in the annulus. DOE considered this volume of waste to be negligible. No analysis of the annular contamination was deemed necessary. DOE concluded that the inventory contributions of the cooling coils, tank walls, equipment and annulus were insignificant compared to the tank floor inventory and were not included in the final Tank 5 inventory.

The tank floor inventory was calculated based on the product of the tank waste concentration, volume, density (wet) and solids content (weight percentage). DOE provided an average, best estimate (95 percent upper confidence limit on the mean), and reasonably conservative (97.5 percent upper confidence limit on the mean) inventory for use in deterministic analyses. DOE also considered uncertainty in the sample concentrations, volume, density and solids content in calculating inventory multipliers (to be multiplied by the "best estimate" inventory) in probabilistic analyses.

Several secondary references listed in SRR-CWDA-2012-00027, Revision 1, were provided with the Tanks 5 and 6 closure module. SRNL-STI-2011-00613 cites SRR-CWDA-2011-00067, Revision 1, "Tank 5 Composite Sample Volumetric Proportions", authored by B. Dean and dated April 2011. This secondary reference was not provided with the closure module but was forwarded by DOE to NRC via email on April 2, 2013. SRR-CWDA-2011-00067 contains final compositing instructions (e.g., sample locations and mass of each sample to be composited) based on final volume estimates. The report also discusses issues with insufficient sample being obtained from one of the samples near the Riser 1 mound when the volume of the Riser 1 mound was significantly greater than originally expected. NRC would note that while final volume estimates show that a significant portion of the residual waste in Tank 5 is associated with the mounds near Risers 1 and 5, DOE significantly under-estimated the volumes of these mounds in initial estimates. The significant underestimation of accumulation volumes led to fewer sample locations and sample material being obtained from these areas then would have been dictated by the volume proportional compositing method had better estimates of volume been initially available.

NRC staff had a number of clarifying questions related to its review of SRR-CWDA-2012-00027, Revision 1. Most notably, NRC staff obtained clarification regarding the relative timing of volume, density, and solids content measurements. DOE indicated that the final volume estimates were made at the same time as sampling but that large changes in volume were not expected over time as waste residuals dried. DOE was unable to explain the differences in Tank 18 (1.1 g/ml) versus Tank 5 (1.35 g/ml) density measurements when questioned by NRC staff. NRC staff also questioned the limited number of cooling coil samples collected for analysis (i.e., only two cooling coil samples—one above and one below the liquid waste level were collected). NRC staff is concerned with the potential for material build-up on portions of the over 4 miles (6400 m) of cooling coils present in each Type I tank. For example, a significant inventory of Pu-238 was left remaining on the walls of Tank 18 due to difficulty in observing material build-up in this tank[2]. DOE indicated that significant advancements have been made in its ability to inspect tank surfaces during waste retrieval and closure activities lending confidence that a significant inventory on the cooling coil surfaces will not be overlooked.

[2] Tank 18 is a Type IV tank, which does not have cooling coils; however, residual material could potentially build up on the surface of cooling coils in the same manner that it could adhere to the walls of a tank.

U-ESR-F-00048, Revision 0, J.L., Clark, “Tank 5 Final Volume Determination and Uncertainty Estimate Report”

U-ESR-F-00048 provides information regarding the final volume estimates for Tank 5. This reference also provides insight with respect to the relative timing of volume estimates and sampling. U-ESR-F-00048 explains that the residual liquid in the tank was allowed to evaporate prior to mapping of residual solids. DOE took high quality digital still photographs of the residual material in Tank 5 in September and December 2010. Sampling activities were performed December 2010 through March 2011. From this information, it would appear that the volume estimates were for partially dried waste. Density measurements were taken shortly after the volume estimates and would be expected to be representative of drier and denser waste[3]. Over 300 high quality photographs and video were taken of the inside of the tank at various elevations to assist with residual solids mapping. Cooling coils and support columns were used in Tanks 5 and 6 to estimate residual solid thickness. DOE later clarified that lifting plates were also used to map residual solids (see also ML13150A219). Characteristics of residual waste were also used to estimate solid thicknesses (e.g., dusting of tank floor [1/32nd inch or 0.08 cm], more extensive curling and cracking estimated [1/16th inch or 0.16 cm], less extensive curling and cracking estimated [1/8th inch or 0.32 cm]). Intact flake samples collected by a sampler crawler were used to corroborate the thickness of dried or flaked samples. Four areas of the tank with similar accumulation heights were mapped separately. Heights were combined and entered into an Excel spreadsheet with each cell in the worksheet representing a 1 ft x 1 ft (0.3 m x 0.3 m) section of the floor. Uncertainty was addressed by estimating a “low end” and “high end” volume of each mapped area and calculating the total low- and high-end volume in Excel. The best estimate volume is 1,900 gallons, with low- and high-end volume estimates of 1,300 (4,900 L) and 2,700 gallons (10,200 L), respectively. Appendix H of U-WSR-F-00048 provides example material heights.

DOE provided one of two secondary references requested by NRC staff: SRNL-L3100-2011-00066, Revision 0, “Estimated Thicknesses of Tank 5 Floor Residue Scrape Samples”, L. N. Oji, April 14, 2011, via email on April 2, 2013. Volume calculation document, M-CLC-F-01256, referenced in SRR-LWE-2010-00240, Revision 0, “Tank Mapping Methodology”, was also requested by NRC. However, DOE indicated that Revision 1 of SRR-LWE-2010-00240 no longer references the calculation document; therefore, the reference was not provided.

NRC staff had a number of clarifying questions related to its review of U-ESR-F-00048. During the March 27-28, 2013, onsite observation (see onsite observation report, ML13113A322), DOE indicated that the same tank mapping methodology employed for Tank 18 was used for Tanks 5 and 6; however, the procedure has been formalized with qualification and training provided to staff performing volume mapping activities. DOE also indicated that Type IV tanks pose the greatest challenges to volume mapping due to the limited number of landmarks present to map residual tank solids, although NRC staff noted that the low end and high end volume ranges for Tanks 18 and 19 were similar to Tanks 5 and 6 (around +/- 30 to 40 percent). DOE indicated that there is a slight bias towards higher volume estimates when making material mapping assignments. The volume estimation program was discussed in more detail during a May 15, 2013 follow-up teleconference (ML13150A219).

[3] NRC staff was concerned that volume estimates could change over time as the waste dried. Because the inventory is calculated from the volume, density, solids content and concentration, and the volume, density, and solids content could change over time, the time variant measurements should be taken at the same time to avoid biases in the calculated inventory or biases should be understood and evaluated.

<u>SRR-LWE-2010-00285, Revision 1, "Tank 5 Sampling and Analysis Plan", and SRR-LWE-2010-00340, Revision 0, "Addendum to Tank 5 Sampling and Analysis Plan"</u>

The Tank 5 sampling and analysis plan contains information on the number and locations of samples, sampling tools to be used, quantity of sample, etc. Sampling of the cooling coils and the tools used to obtain the cooling coil samples is also discussed. SRR-LWE-2010-00285, Appendix A, also contains details regarding the volume proportional sampling approach used. A technical task request (HLE-TTR-2010-004) provides specific details related to sampling of Tank 5.

SRR-LWE-2010-00340 provides an addendum to the sampling and analysis plan. Core sampling of accumulated mounds under Risers 1 and 5 is stated to have resulted in insufficient sample collection. Samples under Risers 1 and 5 were determined to be representative of the upper portion of the mounds. Two sets of two additional samples representing (i) the lower portion of the mound under Riser 1 and (2) the middle and lower portions of the mound under Riser 5 were proposed. A pole scrape sampler was suggested for additional sampling under Riser 1. A crawler equipped with a gripper arm that holds a sample cup was suggested to take additional sample under Riser 5. Sampling and analysis results for Tank 5 are presented in SRNL-STI-2012-00034.

NRC requested secondary reference, HLE-TTR-2010-004, "Technical Task Request, Tanks 5 and 6 Final Sample Analysis", Revision 2, November 10, 2010. DOE provided revision 2 and 7 to the document via email on April 2, 2013.

<u>SRNL-STI-2012-00034, Revision 1, "Analysis of the Tank 5F Final Characterization Samples—2011 (U)"</u>

Tank 5 sample analysis results are provided in this report. Savannah River National Laboratory (SRNL) analyzed the Tank 5 samples from three areas of the tank: (1) mound near Riser 1, (2) mound near Riser 5, and (3) floor scrape samples across the tank. There were 9 floor scrape samples and 6 mound samples. Three sets of 5 samples were composited and analyzed. Bulk density and solids weight fraction were also provided. Separation techniques and analytical methods are presented in Appendix B. Detection limits for certain radionuclides were not met, but the inability to detect these radionuclides was deemed acceptable by project and SRNL staff. SRNL-STI-2012-00034 also provides justification for use of material found in the secondary containment bag when the sample holder for sample 5-B3a-BM was found to be empty, although the sample container for sample 5-B2a-MD, which was not empty, shared the same secondary containment bag.

<u>SRR-CWDA-2012-00075, Revision 0, "Tank 6 Inventory Determination"</u>

SRR-CWDA-2012-00075 summarizes the development of the inventory for Tank 6 and cites several references used to support the inventory development. The sample plan, SRR-LWE-2010-00300, provides information on the number and locations of samples. Screening analyses to determine the constituents to be sampled is provided in SRR-CWDA-2012-00074. Although 15 samples were planned, only 14 samples were obtained after a sampling crawler became entangled on a cooling coil while taking a sample associated with the eastern mound. Justification for using 14 samples versus 15 samples is provided in SRR-CWDA-2011-00159. Sample results are provided in SRNL-STI-2012-00365. Density is also measured to allow conversion of volume estimates to mass. A measurement of solids content of the samples is obtained to convert the dry weight concentration to a wet weight concentration. DOE estimated that 3,000 gallons (11,000 L) of residual waste remained in Tank 6 following waste retrieval. Volume uncertainty is addressed in SRR-LWE-2011-00245. DOE also provided a lower and upper estimate of the residual waste volume of 2,200 gallons (8,300 L) and 4,000 gallons (15,000 L), respectively.

Cooling coil samples taken from Tank 5 were used to reach the conclusion that the cooling coil and tank wall inventory in Tank 6 was insignificant compared to the floor inventory (SRR-CWDA-2012-00027). The cooling coil and tank wall inventory was, therefore, not included in the final inventory. A residual waste volume of 4.7 gallons (18 L) was estimated to be associated with abandoned equipment at concentrations similar to the tank floor. The equipment inventory was assumed to be insignificant compared to the floor inventory (< 1 percent of the volume of residual waste remaining on the floor) and was therefore, not included in the final inventory. DOE estimates 43 gallons (160 L) of waste remain in the annulus (SRR-LWE-2011-00245, SRR-LWE-2012-00102). This volume of waste is <1.7 percent of the floor volume and is therefore also considered to be insignificant compared to the floor inventory.

The tank floor inventory was calculated based on the product of the tank waste concentration, volume, density and solids content. DOE provided an average, best estimate (95th percent upper confidence limit on the mean), and reasonably conservative (97.5 percent upper confidence limit on the mean) inventory for use in deterministic analyses. DOE also considered uncertainty in the sample concentrations, volume, density and solids content in calculating inventory multipliers (to be multiplied by the "best estimate" inventory) in probabilistic analyses. Note: SRNL-STI-2011-00323 reviews the approach used to consider volumetric uncertainty in the compositing process. SRNL-STI-2011-00323 notes that the approach to estimating low, best-estimate and high volumes is not specifically evaluated.

Based on NRC staff's review of SRR-CWDA-2012-00075, Revision 0, NRC staff questioned DOE's basis for conclusions regarding the risk of annular waste in Tanks 5 and 6 during the March 27-28, 2013, onsite observation. DOE indicated that the volume of annulus waste is expected to be insignificant compared to the tank floor waste volume; therefore, no annular inventory was specifically considered. NRC staff noted the following: (1) a significant percentage of the annulus in Tank 6 was stated to not be visible using cameras in each of 4 risers; therefore, there may be significant uncertainty associated with the estimated waste volumes, (2) annular contamination is located outside of the tanks; therefore, it is not clear that the risk of inventory in the annulus is directly related to the relative volume of waste in the annulus versus the tank (relatively low volume was used as a basis for excluding the inventory), and (3) highly soluble species present in the supernate may be present in higher concentrations in the annulus and may be more risk-significant owing to the greater mobility of these species in the environment. During the March 27-28, 2013, onsite observation, DOE clarified that 100 percent of the annulus was inspected in deriving the annulus volume estimates (see onsite observation report, ML13113A322). NRC acknowledged that if the volume of annular waste was below some risk-significant threshold, then the risk of the annular waste was low. However, DOE should have confidence that the estimated annular waste volumes are not significantly underestimated and should understand the risk of relatively more soluble materials and short-lived radionuclides residing outside of primary containment.

NRC requested two secondary references cited in SRR-CWDA-2012-00075, Revision 0: (1) SRR-CWDA-2011-00172, Dean, W.B., "Tank 6 Composite Samples Volumetric Proportions", Savannah River Site, Aiken, SC, Rev. 0, November 10, 2011 and (2) SRNL-RP-2010-01695, Oji, L.N., et al., "Task Technical and Quality Assurance Plan for Analysis of the Tank 5F and

Tank 6F Final Characterization Samples-2011", Savannah River Site, Aiken, SC, Rev. 1, November 30, 2011. These secondary references were provided via email on April 2, 2013.

SRR-LWE-2010-00300, Revision 1, "Tank 6 Sampling and Analysis Plan", SRR-LWE-2011-00209, "Tank 6 Sampling and Analysis Plan Addendum", and SRR-LWE-2011-00235, Revision 0, "Tank 6 Sampling and Analysis Plan Addendum 2"

The Tank 6 sampling and analysis plan contains information on the number and locations of samples, tools to be used to take the samples, and quantity of samples to be used in the analysis. Based on lessons learned from Tank 5 sampling, DOE collected subsurface scrape samples associated with accumulations or mounds (in addition to core sampling of the mounds). Appendix A also contains details regarding the volume proportional sampling approach used. A technical task request (HLE-TTR-2010-004) provides specific details related to sampling of Tank 6. Two addendums to the original sampling plan were developed to (i) amend scrape sample locations to the north to sample a newly identified mound to the northeast that was not identified until review of sample crawler video, and (ii) to document the change in the number of samples from 15 to 14 samples when a sampling crawler was entangled in a cooling coil.

Based on its review of the sampling and analysis plans for Tank 6, NRC staff questioned the selection of five (5) samples near Risers 1 and 3 (SRR-LWE-2010-00300, Revision 1) when the volume was only 150-250 gallons (570-760 L). This is in comparison to three (3) planned samples under Riser 5 when the volume was estimated at 800-1,200 gallons (3,000 to 4,500 L). During the March 27-28, 2013, onsite observation, DOE indicated that this was a lesson learned that was incorporated into future compositing schemes. NRC also indicated that it was not clear from the addendum (SRR-LWE-2011-00209) if the three newly proposed samples replaced the samples near Riser 1 or other scrape samples to the north. DOE indicated that the floor samples to the north should have been eliminated from the figure in SRR-LWE-2011-00209. DOE indicated that SRR-CWDA-2011-00159 shows the final sample locations. SRR-CWDA-2011-00159 also provides justification for use of 14 (instead of 15) samples with one less sample associated with the northeast mound and for the collection of all samples to the south/central of the mound near Riser 5 (instead of a few samples to the north) due to sample crawler access limitations.

SRR-LWE-2011-00245, Revision 2, J.L., Clark, "Tank 6 Final Volume Determination and Uncertainty Estimate"

Video and still photographs of the interior of the tank following waste retrieval operations were used to map the residual solids volume in Tank 6. Video cameras were placed in Risers 2, 7, and the center riser during sampling. Additionally, cameras were installed on sample crawlers. Video taken during sampling was also used to supplement still photos. Cameras were placed in north, south, east, and west risers in the annulus. Due to the curvature of the tank large areas of the annulus floor were stated to not be visible. Therefore, visible areas of the annulus that could be inspected were used to extrapolate volumes in other areas of the annulus. The same tank landmarks used to map residual solids in Tank 5 (U-ESR-F-00048) were used to map solids in Tank 6 (e.g., cooling coils/support structures, support columns, sample crawler). Unlike the approach used for Tank 5, only one hand drawn map of the residual solids volume was used to estimate the volume. Areas of similar height are marked on the hand drawn map and the material heights in these areas are input to an Excel spreadsheet to calculate residual material volume. The best-estimate volume is 3,000 gallons (11,000 L) with a lower-end and higher-end volume of 2,200 gallons (8,300 L) and 4,000 gallons (15,000 L).

SRNL-STI-2012-00365, Revision 0, "Analysis of the Tank 6F Final Characterization Samples-2012 (U)

SRNL-STI-2012-00365 provides information on the sampling results for Tank 6. Three areas of the tank were delineated with 14 samples total (one sample could not be obtained). In response to NRC inquiry, DOE stated that the "as-received" samples from Tank 6 in Figure 1 look markedly different than the samples taken from Tank 5 due to the use of supernate during mechanical feed and bleed. SRNL-STI-2012-00365 also indicates that "Samples from planned locations along the north side of the solids accumulation under riser 5 in Tank 6F were actually collected from the central/south region. This was determined by SRR to be acceptable because of process history and because the solids appearances in the tank photos indicate that the Tank 6F solids were well-mixed." DOE is referring to intermediate volume mapping that DOE indicates supports its conclusion that waste mounds were mobilized during later stages of waste removal. It is not clear to NRC staff that this is the case as discussed in more detail below. The number of samples taken from each mound is disproportionate to the amount of volume in each mound. The basis for the sampling locations is not clear to NRC staff.

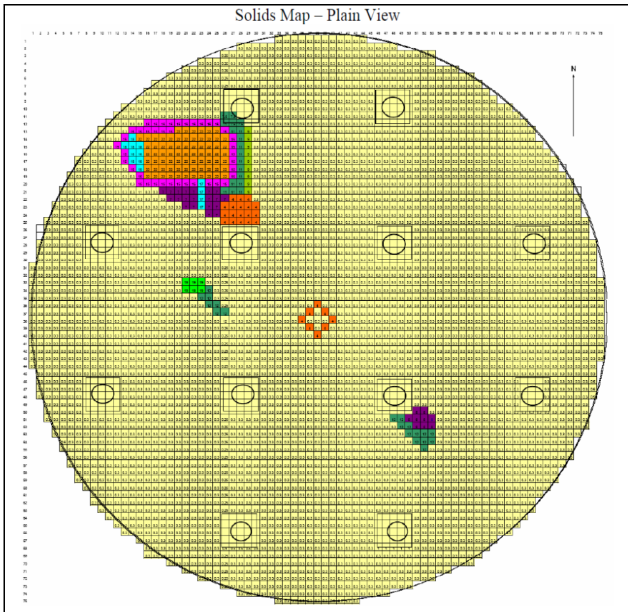
NRC Staff Evaluation:

Sampling and Analysis

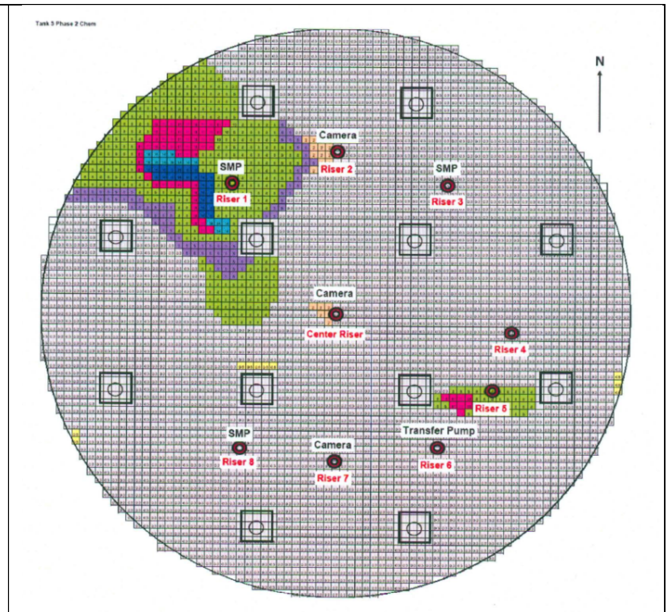
With exceptions noted below, NRC finds the sampling and analysis methodology presented by DOE in the Liquid Waste Tank Residual Sampling and Analysis Program Plan to be generally acceptable. NRC also finds sampling and analysis of Tank 5 and Tank 6 residual solid waste adequate for the purposes of performance assessment calculations. A number of technical concerns were identified during the review and are presented below for DOE's future consideration.

The impact of cleaning operations on the alteration and redistribution of sludge residuals should be considered in the sampling plan and design. While the solids in Tank 5 may have been well mixed during various stages of sludge removal, it is not clear that the solids were well mixed at the end of cleaning operations[4]. For example, the Riser 1 solids that were mobilized during mechanical sludge removal accumulated near Riser 1 during the first oxalic acid strike likely because the Riser 1 Submersible Mixing Pump (SMP) was not used during chemical cleaning (see Figure 3). Although a Submersible Mixing Pump was operated in Riser 1 during mechanical feed and bleed and the Riser 1 accumulation was reduced and flattened by the end of cleaning operations, the accumulation near Riser 1 persisted from the end of the first chemical cleaning strike to the end of mechanical feed and bleed (see Figure 3). Challenges experienced during chemical cleaning led to the formation of metal oxalates that are thought to have hampered subsequent chemical cleaning campaigns in Tanks 5 and 6. Oxalate precipitates that may have made it more difficult to treat tank sludge, could have also led to differences in radiological composition between waste in more direct contact with oxalic acid and waste that was buried in tank accumulations. While material at the bottom of the tank

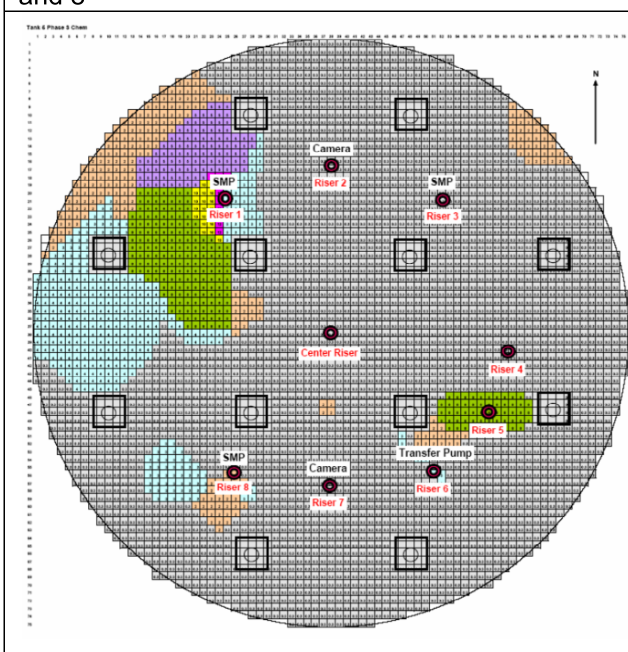
[4] It is also important to note that interim volume mapping conducted during cleaning campaigns is not as accurate as final volume mapping due to such factors as the presence of an approximately 2 inch residual liquid level that makes it difficult to map residual solids nearer the tank bottom and due to visibility issues. For example; initial Tank 5 estimates significantly under-predicted the volume of waste associated with riser accumulations. Poor visibility due to tank obstructions led to uncertainty in the intermediate residual solids mapping in Tank 6 (e.g., the northeast accumulation in Tank 6 was not visible until sampling).



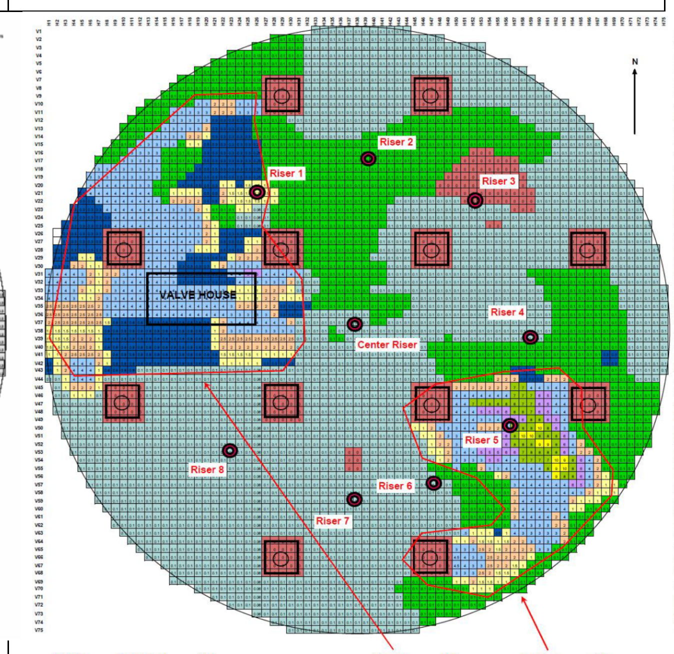
Volume Mapping After Chemical Sludge Removal 1 (from M-ESR-F-150)
Liquid level 2 inches, 22 inches maximum thickness
Submersible Mixer Pumps operated in Risers 3 and 8



Volume Mapping After Chemical Sludge Removal 2 (from M-ESR-F-00158)
Liquid level 2 inches, 16 inches maximum thickness



Volume Mapping After Chemical Sludge Removal 3 (from M-ESR-F-00160)
Liquid level 2 inches, 12 inches maximum thickness



Volume Mapping Mechanical Feed and Bleed (from U-ESR-F-00048)
5 inch maximum thickness
Submersible Mixer Pumps operated in Risers 1, 3, and 8

Figure 3 Distribution of Solid Residuals Following Initiation of Oxalic Acid Chemical Cleaning in Tank 5

accumulations appears to have been mobilized to a certain extent during mechanical feed and bleed, access limitations that constrained sample collection and the limited number of mound samples that were composited with other tank samples makes it perhaps more challenging to obtain information on variability between or within segments that could exhibit heterogeneity (e.g., waste residual mounds could be more heterogeneous compared to thin accumulations across the tank; the inner, bottom portion of a mound could be heterogeneous relative to the outer, top portion of a mound).

With respect to segment variability, it is not clear why DOE does not pursue the option to composite within segments to preserve information on *intra*-segment variability. DOE analyzes three composite samples in triplicate for a total of nine analyses. DOE could obtain a subset of the total number of samples taken from each segment (e.g., set of two or three samples from a total of five or six samples taken from a particular segment) for composite analysis. This activity could be repeated three times to obtain sufficient data to perform a statistical analysis of *intra*-segment variability. This approach would serve to preserve information on individual segments that is currently lost in the current compositing scheme in which samples from the entire tank are composited for analysis. While additional compositing of segment samples or the need for additional segment samples to support segment compositing may incur additional costs, the same number of composites could undergo separations and analysis that may represent the bulk of the costs. The costs and benefits of *intra*-segment compositing should be evaluated. Intra-segment compositing could also be used to address any future NRC concerns regarding the extent to which accumulated mounds are different than other residual waste or differences in the effectiveness of chemical treatment within a mound.

DOE analyzes each of three composite samples in triplicate for a total of nine analyses. While sampling in triplicate provides information on measurement uncertainty, the variance between composite samples may be artificially decreased when all composite samples and triplicate measurements are combined. Accordingly, the calculated 95th percent upper confidence limit on the mean appears underestimated. DOE should separately quantify measurement uncertainty (and errors in homogenization of composite samples) and sample uncertainty to enhance the presentation of information and derive appropriate confidence estimates on the average radionuclide concentration. DOE considered the relative contributions of sampling and measurement uncertainty for Tanks 5 and 6 sampling (see for example SRNL-STI-2011-00613, Rev. 1); however, the process and results are not transparent and it is not apparent that standard analysis of variance (ANOVA) formulas, such as those compiled by Menzel (1960), were used.

To alleviate the burden with analyzing composites in triplicate, DOE could analyze a subset of composites in triplicate to better quantify the relative contribution of measurement uncertainty and errors in homogenization of composite samples, and if not found to be significant, then DOE could save analytical costs on triplicate analyses for other composite samples. In some limited cases, measurement uncertainty and homogenization errors may be greater than composite variability and may dominate overall uncertainty in the mean radionuclide concentration. However, if measurement uncertainty and homogenization errors do not dominate the overall uncertainty, then additional composites to better characterize composite sample representativeness and intra-segment variability may be more cost-beneficial and informative. DOE should evaluate and clearly communicate the relative contributions of various forms of uncertainty related to the sampling process on estimates of the confidence bounds of average concentrations on a radionuclide-specific basis.

DOE should ensure that samples are taken from various intervals or strata within an accumulation. While this approach is consistent with the sampling plan, in some cases difficulties arise in obtaining samples from waste accumulations in certain areas of the tanks that are more difficult to access. For example, DOE carried out evaluations to determine the impact of the inability to obtain samples from certain locations in Tank 6 and provided “mixing” arguments to justify the number and location of samples taken (see discussion in SRR-CWDA-2011-00159). Mixing may be less effective and heterogeneity greater in areas of the tank that are less accessible to sampling due to physical obstructions such as cooling coils. Additionally, the quantity and number of samples taken from each segment appears disproportionate to the relative volume of the segment. This appears to be partially a result of the significant errors in early estimates of segment volumes prior to sampling activities at which time additional information was collected to refine the volume estimates. While in general, the methodology presented in the Liquid Waste Sampling and Analysis Program Plan and Sampling and Analysis Plans is well reasoned and sound, successful execution of the plans may be compromised due to sparse sampling, access limitations, or sample tool/collection issues that are difficult to overcome. Adequate management and mitigation of issues arising from sample heterogeneity, access limitations, and difficulty with sample collection will increase the technical defensibility of final inventory estimates. Continuous improvement and clear instruction on how to overcome sampling difficulties will help avoid workarounds, which are later difficult to justify, in future tanks sampling efforts and lend credence to final inventory estimates used for performance assessment calculations.

NRC performed scoping calculations to better understand DOE’s approach to calculate the 95th percent upper confidence level (UCL 95) on the mean for the performance assessment. Data obtained from SRNL-STI-2011-00613, Revision 2, and SRNL-STI-2012-00365, Rev. 2, for Tanks 5 and 6, respectively, were used in these scoping calculations. Comparison of results between (i) more rigorous goodness of fit and analysis of variance methods used by DOE and (ii) possibly more intuitive methods such as bootstrap, or naïve statistical methods such as using a normal distribution with a standard deviation equal to the standard error in the mean (i.e., the sample standard deviation divided by the square root of the number of samples [=9]) revealed minor differences in the calculated inventory between the various methods tested. The NRC scoping computations indicate that DOE computations are equivalent to considering 9 independent measurements per radionuclide. More significant differences were identified when NRC computed the mean of three measurements per sample, and then computed the UCL95 in the mean using a 0.975 quantile of the student t distribution with 2 degrees of freedom, and a standard deviation in the mean computed as $\sigma/\sqrt{3}$, where σ is the standard deviation of the three composite sample averages. It is not clear why DOE used all 9 measurements as if they were practically independent, to compute the UCL95. As stated previously, such an approach gives the appearance to underestimate the UCL95. DOE should clarify the statistical approach to estimate the UCL95.

With regard to screening analyses, SRR-CWDA-2012-00074, “Tanks 5 and 6 Radionuclide and Chemical Screening for Residual Inventory Determination”, presents the results of screening analyses and basis for elimination of five radionuclides from the list of radiological constituents to be analyzed in residual tank wastes. The basis for the elimination of the five radionuclides from Tank 6 sampling appears reasonable given that Tank 6 has similar waste as Tank 5[5]. If, in

[5] Elimination of radionuclides from the list of constituents to be analyzed should be based on risk arguments (e.g., lack of risk-significant inventory in tank waste). DOE should continue to analyze all highly radioactive radionuclides unless it can eliminate a radionuclide based on the lack of detection in

the future, additional radionuclides are eliminated from the list of radionuclides to be analyzed in tank wastes based on the radionuclide's non-detection in previous analyses, NRC staff should evaluate the minimum detectable concentration (MDC) in the previous analyses to ensure that the MDC is sufficiently low such that the risk associated with the radionuclide being present at the MDC, based on performance assessment calculations, is insignificant. If the MDC of a radionuclide is relatively high, then arguments for the elimination of the radionuclide from further analysis based on (i) lack of identification of the radionuclide in other tanks wastes and (ii) low risk are not compelling—the radionuclide could be present at concentrations lower than the MDC and still be a radionuclide of concern, if the actual concentration of the radionuclide in tank wastes were known.

NRC will continue to monitor DOE's tank sampling and analysis program under Monitoring Factor 1.2 "Residual Waste Sampling". NRC expects DOE to address the following technical concerns in future tank sampling efforts that are not specifically discussed in the monitoring plan for F-Tank Farm (ML12212A192):

- DOE should consider, in its tank sampling design, historical information on tank waste receipts, and information related to the alteration and redistribution of waste due to cleaning operations that may impact horizontal and vertical waste heterogeneity.
- DOE should evaluate the option to composite samples within segments (or strata) to preserve information about segment (or strata) variance.
- DOE should evaluate and present information on the relative contributions of various forms of uncertainty in its estimation of mean tank concentrations.
- DOE should clarify the statistical approach used to estimate the UCL95 (e.g., treatment of all 9 measurements as independent when computing the UCL95).
- DOE should also consider how it can better assure sample representativeness by improving tank sampling designs, collection tools and instructions.

Alternatively, DOE could manage sampling and analysis uncertainty through use of estimates that clearly err on the side of higher inventories. These technical concerns do not need to be addressed until the next tank sampling effort is conducted.

NRC will also continue to monitor, as applicable, DOE arguments related to the elimination of radionuclides from the list of constituents to be analyzed under Monitoring Factor 1.2. With regard to Monitoring Factor 1.4, "Ancillary Equipment Inventory", DOE indicated that it still has plans to sample ancillary equipment but has not yet developed documentation to perform this activity. As documented in NRC staff's F-Area Farm Monitoring Plan, Monitoring Factor 1.4, "Ancillary Equipment Inventory", NRC staff will monitor DOE's efforts to verify assumptions regarding the relatively low risk of ancillary equipment through sample and analysis.

Notwithstanding the technical concerns enumerated above, NRC finds DOE's proposed methodology to develop final inventory estimates for F-Tank Farm tanks generally adequate. NRC also finds the implementation of the sampling and analysis approach for Tanks 5 and 6 appropriate for use in F-Tank Farm performance assessment calculations.

<u>Volume Estimation</u>

---

tanks with similar waste. In other words, DOE should not use Tank 5 analytical results to eliminate radionuclides from analysis for tanks that have significantly different waste characteristics.

Based on review of U-ESR-F-0048 and SRR-LWE-2011-00245, Rev. 2, the approach to developing the volume estimates appears to be technically sound and adequately executed. However, it is less clear that volume uncertainty is adequately managed in this area. Reliance on the human eye and photographic and video tools to ascertain residual thicknesses that are a fraction of inch are expected to be highly uncertain. The impact of low volume uncertainty is expected to be limited for Tanks 5 and 6, given the fact that areas of the tank with small residual thickness have minimal volume compared to other areas of the tank where thicker accumulations of waste remain. While DOE attempted to experimentally validate relatively low residual solids thicknesses based on waste characteristics (e.g., flake characteristics), it is possible that residual solids located underneath the surface of dried and cracked residual solids adds to the thickness but cannot be easily discerned. In certain cases the error introduced by visual mapping of solid accumulations may be more significant than assumed and should be better understood possibly through field validation efforts. For example, there is a large thickness range between flaky waste and the bottom of the lower cooling coil in areas where column supports and lifting plates are not available to estimate intermediate thicknesses. If a significant fraction of the volume is associated with thinner accumulations, then field validation of thicknesses can be used to obtain more accurate volume estimates and to better quantify uncertainty in solids mapping.

Uncertainty in volume estimates is addressed through use of a triangular distribution with low and upper end volume estimates assigned based on the same mapping technique used to develop the best estimate volume. In general, mappers appear to default to the next lower or next higher discrete thickness used in the reference case mapping when assigning bounding values to specific areas of the tanks. The reference case thickness is based in large part on the landmarks available to assign thicknesses for the particular tank being mapped. Fewer landmarks or tools are available to assign thicknesses a fraction of an inch. NRC staff observed relatively large spacing between discrete thicknesses assigned at the low range (e.g., in Tank 5 there is a factor of 2 difference between thicknesses assigned on the lower range: 1/32, 1/16, 1/8, ¼, and ¾ of an inch [1 inch=2.54 cm]) and it is expected that mapping solid residuals below 1 inch (2.54 cm) is relatively more uncertain (i.e., uncertainty may be greater than mappers assume). At relatively greater thicknesses, mappers appear to be more confident in assigning intermediate depths between landmark heights (e.g., mappers appear to assign solids heights at an accuracy of about 0.5 to 1 inch (1.24 to 2.4 cm) at greater thicknesses: 1, 1.5, 2, 2.5, 3, 4, 4.5, 5, 7, 8, 9, 10 in [1 inch=2.54 cm]). For intervals above 1 inch [2.54 cm], relative errors are assumed by mappers to be much less—around 50 percent or less as thickness increases. So while relatively greater uncertainty is expected to exist at heights that are a fraction of an inch, if most of the volume is located in thicker accumulations, the relatively greater uncertainty in thin accumulation volumes may not be risk-significant because there is just not enough volume to be important. On the other hand, if a significant fraction of the volume is located in very thin accumulations, then uncertainty ranges of +/- 30 to 40 percent are likely understated. Field validation can be used to manage this uncertainty. However, bounding assumptions regarding the volume estimates may be more cost effective if these assumptions lead to acceptable results. Bounding assumptions can be made through limited field validation to estimate the potential range in error for various solid material heights.

For thicker accumulations, it is expected that significant uncertainty is introduced by the discretization of mapping areas of similar height, the delineation of discretized mapping areas on hand contoured maps, and the transfer of hand contoured maps to a volume mapping spreadsheet that has a relatively fine 1 ft by 1 ft (0.3 m by 0.3 m) discretization. The mappers make subjective decisions on assigning areas of similar height and in assigning the heights themselves when in actuality the solid material heights are not uniform across the delineated areas. All of these uncertainties must be integrated and processed by the team of mappers when assigning best-estimate, as well as high and low end heights. With regard to assignment of material height ranges, if the mapper tends to bound the height estimates (e.g., by assigning a minimum/maximum height that is thought to be clearly below/above the non-uniform surface of the delineated areas), then the range of volumes considered in the uncertainty analysis will likely be bounding.

With regard to annular residual solids mapping, Tank 6 documentation indicates that waste volumes are estimated through use of cameras placed in four annulus risers. A significant fraction of the annulus is not visible using this method. During the March 27-28 onsite observation, DOE clarified that 100 percent of the Tank 5 and 6 annuli were inspected using crawlers (see onsite observation report, ML13113A322). During the May 15, 2013 teleconference (ML13150A219), DOE indicated that crawlers *may* [sic] be used to inspect tank annuli (SRR-CWDA-2013-00072), and DOE provided video of annulus inspections in Tanks 5 and 6 west risers (ML13142A149) to demonstrate the use of video to map solid residual volumes. However, it is not clear that all areas of the Tank 5[6] and in particular the Tank 6 annuli were inspected through supplemental use of video from crawlers to estimate residual solids volume. DOE should be more transparent in describing how the annular volume is estimated in areas that are not visible including use of a crawler to supplement riser cameras. Additionally, if significant inventory is potentially present in the ventilation duct of an annulus, then it is not clear that DOE would be able to estimate the volume of waste in the ventilation duct with a high degree of accuracy given that the majority of waste is not clearly visible. Registers representing a small fraction of the ventilation duct area are located at the top of the ventilation duct several feet from one another providing access for cameras, but large areas of the ventilation duct are not visible. Residual waste in ventilation ducts are expected to be more of a concern for H-Area Tank Farm annuli, however, based on information currently available to NRC.

With regard to cooling coil inventory, DOE does not expect the cooling coil inventory to be significant. Because DOE experienced difficulty with visualization of scale build-up on Tank 18 tank walls, due to visibility arguments alone, it was not immediately obvious to NRC that DOE would be able to provide a strong basis that two cooling coil samples were sufficiently representative for the over 4 miles (6400 m) of cooling coils located within each tank. This comment also applies to the tank walls. NRC staff reviewers will continue to evaluate DOE's efforts to inspect cooling and tank walls to ensure there is no significant inventory remaining on the surfaces of in-tank components. While improvements have been made to the technology used to inspect tank surfaces, it is not clear that DOE would be able to inspect a large fraction of the extensive network of cooling coils given the quantity of high definition photographs and video that would need to be taken at various heights and angles to accomplish this task. DOE should provide estimates of the fraction of cooling coils that are inspected during cleaning/sampling operations and/or present arguments why it thinks cleaning operations are sufficiently effective in removing solids from internal tank surfaces to support its assumption that no significant solids material build-up is overlooked on cooling coils and tank surfaces during cleaning and sample and analysis.

NRC will continue to monitor DOE's tank waste volume estimation program under Monitoring Factor 1.3 "Residual Waste Volume". NRC expects DOE to address the following technical concerns when estimating residual tank waste volumes in the future. These concerns are not specifically discussed in the monitoring plan for F-Tank Farm (ML12212A192):

---

[6] U-ESR-F-00048 also indicates that 100 percent of the Tank 5 exterior wall was inspected for leak sites. The crawler used to inspect Tank 5 could have also been used to inspect the Tank 5 annulus.

- DOE should better understand the accuracy of mapping team height estimates through additional field validation activities for a range of solid material heights.
- DOE should clearly communicate how it determines the size of areas to be mapped and how it manages uncertainty related to height estimates for discretized areas in its deterministic analysis. Likewise, DOE should clarify how it represents uncertainty in the assignment of high and low end heights to these areas (e.g., does it use a height that is clearly below/above the non-uniform surface of the delineated areas).
- DOE should consider uncertainty in the volume estimates resulting from the transfer of data from photographic and video evidence to hand contoured maps (and then to Excel spreadsheets with a finer discretization).
- DOE should be more transparent with respect to its approach to (i) mapping annular volumes including use of a crawler to inspect internal surfaces and (ii) estimating residual waste volumes in ventilation ducts. DOE should consider uncertainty in annulus volume estimates.

Alternatively, volume mapping uncertainty could be managed through use of estimates that clearly err on the side of higher volumes. These technical concerns do not need to be addressed by DOE until the next tank volume mapping exercise.

Additionally, NRC staff will continue to monitor DOE's ability to inspect internal surfaces of the tanks to ensure significant volumes of residual waste remaining in the tank are considered in the inventory estimates under Monitoring Factor 1.3 (see monitoring plan for F-Tank Farm found at ML12212A192).

Notwithstanding the technical concerns enumerated above, NRC finds DOE's proposed methodology to develop final inventory estimates for F-Tank Farm tanks generally adequate. NRC also finds DOE's Tanks 5 and 6 volume estimates appropriate for use in F-Tank Farm performance assessment calculations.

<u>Teleconference or Meeting:</u>

Tanks 5 and 6 inventory development was discussed at an onsite observation held at SRS on March 27 and 28, 2013. The March 27-28, 2013, onsite observation report (ML13113A322) provides a summary of the onsite observation including a detailed list of NRC questions and DOE answers provided on Tanks 5 and 6 inventory.

Following the onsite observation, a follow-up teleconference was held on May 15, 2013, on the Tanks 5 and 6 inventory and volume mapping methodology (ML13150A219). DOE provided video on tank and annulus inspection of Tanks 5 and 6, as well as a presentation that more clearly documented the tank mapping methodology used for these tanks (ML13142A149) to support the teleconference. Additionally, DOE and NRC held a follow-up teleconference on May 8, 2013, related to the Tanks 5 and 6 Special Analysis (ML13133A125 and ML13142A084). During the May 8th teleconference, the final inventory development for Tanks 5 and 6 was put into context with the inclusion of performance assessment calculations to help better understand the risk-significance of the overall tank, as well as individual key radionuclide inventories. The development of inventory distributions and final Tank 5 and 6 risk estimates is evaluated in a separate technical review report related to Monitoring Factor 1.1, "Final Inventory and Risk Estimates" listed in NRC staff's plan for monitoring F-Tank Farm (ML12212A192) that will be issued later this year.

Follow-up Actions:

NRC staff will continue to monitor DOE's tank sampling and analysis program under Monitoring Factor 1.2 "Residual Waste Sampling" listed in NRC staff's plan for monitoring F-Tank Farm (ML12212A192) focusing on the technical concerns listed in this review report.
NRC staff will also continue to monitor DOE's tank volume estimation program under Monitoring Factor 1.3 "Residual Waste Volume" listed in NRC staff's plan for monitoring F-Tank Farm (ML12212A192) focusing on technical concerns listed in this review report.

Key findings and conclusions related to this review were discussed with DOE during the August 27-28, 2013, onsite observation. NRC staff expects DOE to address the technical concerns listed in this review report, which are not explicitly identified in NRC staff's monitoring plan, when developing inventories for F-Tank Farm tanks in the future. In general, inventory is considered by NRC staff to be of high risk-significance. However, the technical concerns identified by NRC staff in this report are collectively considered to be of moderate risk-significance based on their importance to NRC staff's conclusions regarding F-Tank Farm compliance with the performance objectives in 10 CFR Part 61, Subpart C.

Open Issues:

There are no open issues associated with DOE's program for estimating final tank inventories. Treatment of tank inventory uncertainty will be evaluated in a separate technical review report related to the Tanks 5 and 6 Special Analysis.

Conclusions:

As a result of review of several DOE documents related to the development of the Tank 5 and Tank 6 final inventories, NRC staff concludes that DOE has made several improvements to its tank sampling and volume estimation programs. A sampling and analysis program plan was developed, which generally provides a technically sound approach to developing tank inventories in the future. Training and procedures have also been developed to help formalize the tank residual volume mapping program. All of these improvements have led to a more technically defensible program. NRC staff has listed several technical concerns related to Monitoring Factors 1.2 and 1.3 and therefore, these Monitoring Factors will remain open at this time. NRC staff will monitor progress on these technical concerns as tank farm closure progresses. When NRC staff determines that the technical concerns have been addressed, NRC staff may decide to close these Monitoring Factors. If Monitoring Factors 1.2 and 1.3 are closed before development of final inventories for all F-Tank Farm tanks, NRC staff will perform a more cursory review of final inventory development under Monitoring Factor 1.1 "Final Inventory and Risk Estimates".

References:

HLE-TTR-2010-004, Revision 2, "Technical Task Request: Tanks 5 and 6 Final Sample Analysis", Closure and Waste Disposal Authority, November (2010).

HLE-TTR-2010-004, Revision 7, "Tanks 5 and 6 Final Sample Analysis and Data Validation Support", Closure and Waste Disposal Authority, June (2012).

Menzel, Donald H, "Fundamental Formulas of Physics", Chapter 2.11 Analysis of Variance, New York, Dover Publications, Inc., 1960.

NRC, "U.S. Nuclear Regulatory Commission Plan for Monitoring Disposal Actions Taken by the U.S. Department of Energy at the Savannah River Site F-Area Tank Farm Facility in Accordance with the National Defense Authorization Act for Fiscal Year 2005," ML12212A192, January (2013).

NRC, "Summary of May 8, 2013, Clarifying Teleconference Call Between the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy Regarding F-Area Tank Farm Tanks 5/6 Special Analysis for the Savannah River Site", ML13133A125, June (2013).

NRC, "Summary of the May 15, 2013, Clarifying Teleconference Call Between the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy Regarding F-Area Tank Farm Volume Mapping and Inventory for the Savannah River Site", ML13150A219, June (2013).

NRC, "Tanks 5 and 6 Annulus Inspection Videos at the F-Area Tank Farm at the Savannah River Site", ML13142A149, May (2013).

SRNL-L3100-2011-00066, Revision 0, L.N., Oji, "Estimated Thicknesses of Tank 5 Floor Residue Scrape Samples", Savannah River National Laboratory, Savannah River Nuclear Solutions, LLC, Aiken, SC, April (2011).

SRNL-RP-2010-01695, Revision 1, L.N. Oji, D. Diprete, C. Coleman, "Task Technical and Quality Assurance Plan for Analysis of the Tank 5F and Tank 6F Final Characterization Samples-2011 (U)", Environmental and Chemical Process Technology Research Programs Section, Savannah River National Laboratory, November (2011).

SRNL-STI-2010-00386, Revision 0, L.N. Oji, D. Diprete, and C.J. Coleman, "Characterization of Additional Tank 18F Samples", Savannah River National Laboratory, Savannah River Nuclear Solutions, LLC, Aiken, SC, September (2010).

SRNL-STI-2011-00323, Revision 0, E.P. Shine, "Technical Review of the Method of Constructing Composite Samples with Uncertain Volumetric Proportions (U)", Computational Sciences, Savannah River National Laboratory, Aiken, SC May (2011).

SRNL-STI-2011-00613, Revision 1, E.P. Shine, "Statistical Analysis of Tank 5 Floor Sample Results (U)," Computational Sciences, Savannah River National Laboratory, Aiken, SC, August (2012).

SRNL-STI-2011-000323, Revision 0, E.P. Shine, "Technical Review of the Method of Constructing Composite Samples with Uncertain Volumetric Proportions (U)", Computational Sciences, Savannah River National Laboratory, Aiken, SC, May (2011).

SRNL-STI-2011-00372, Revision 0, L.N. Oji, D.P. Diprete, “Characterization of Tank 5F Vertical Cooling Coil Leachates for Select Radionuclides-2011”, Savannah River National Laboratory, Savannah River Nuclear Solutions, LLC, Aiken, SC, August (2011).

SRNL-STI-2012-00034, Rev. 1, L. N. Oji, D. Diprete, C. J. Coleman and M. S. Hay, “Analysis of the Tank 5F Final Characterization Samples—2011 (U)”, August (2012).

SRNL-STI-2012-00365, Revision 0, L. N. Oji, D. P. Diprete, C. J. Coleman, M. S. Hay and E. P. Shine, “Analysis of the Tank 6F Final Characterization Samples-2012 (U)”, Savannah River National Laboratory, Savannah River Nuclear Solutions, LLC, Aiken, SC, June (2012).

SRR-CWDA-2011-00050, Revision 1, “Liquid Waste Tank Residuals Sampling and Analysis Program Plan”, Savannah River Remediation, LLC, Closure and Waste Disposal Authority, Aiken, SC, February 2012.

SRR-CWDA-2011-00067, Revision 1, “Tank 5 Composite Samples Volumetric Proportions”, Savannah River Remediation, LLC, Savannah River Site, Aiken, SC, April (2011).

SRR-CWDA-2011-00117, Revision 0, “Liquid Waste Tank Residuals Sampling—Quality Assurance Program Plan”, Savannah River Remediation, LLC, Closure and Waste Disposal Authority, Aiken, SC, February (2012).

SRR-CWDA-2011-00159, Revision 0, “Justification for Changes to the Tank 6 Sampling and Analysis Plan”, Savannah River Remediation, LLC, Closure and Waste Disposal Authority, Aiken, SC 29808, November (2011).

SRR-CWDA-2011-00172, Revision 0,“Tank 6 Composite Samples Volumetric Proportions”, Savannah River Remediation, LLC, Savannah River Site, Aiken, SC, November (2011).

SRR-CWDA-2012-00027, Revision 1, “Tank 5 Inventory Determination”, Savannah River Remediation, LLC, Closure and Waste Disposal Authority, Aiken, SC, August (2012).

SRR-CWDA-2012-00075, Revision 0, “Tank 6 Inventory Determination”, Savannah River Remediation, LLC, Closure and Waste Disposal Authority, Aiken, SC, August (2012).

SRR-CWDA-2012-00074, Revision 0, “Tanks 5 and 6 Radionuclides and Chemical Screening for Residual Inventory Determination”, Savannah River Remediation, LLC, Closure and Waste Disposal Authority, Aiken, SC, May (2012).

SRR-CWDA-2013-00072, “Savannah River Site F-Tank Farm NRC Onsite Observation Visit Follow-up Discussions Waste Tank Mapping Methodology”, Savannah River Remediation, Savannah River Site, Aiken, SC, May (2013).

SRR-LWE-2010-00240, Revision 1, J. Clark, “Tank Mapping Methodology”, Closure Project Engineering, Savannah River Remediation, LLC, November (2012).

SRR-LWE-2010-00285, Revision 1, “Tank 5 Sampling and Analysis Plan”, Liquid Waste Operations Closure Project Engineering, November (2010).

SRR-LWE-2010-00300, Revision 1, “Tank 6 Sampling and Analysis Plan”, Liquid Waste Operations, Closure Project Engineering, January (2011).

SRR-LWE-2010-00340, Revision 0, “Addendum to Tank 5 Sampling and Analysis Plan”, Liquid Waste Operations, Closure Project Engineering, December (2010).

SRR-LWE-2011-00209, “Tank 6 Sampling and Analysis Plan Addendum”, Liquid Waste Operations, Closure Project Engineering, August (2011).

SRR-LWE-2011-00235, Revision 0, “Tank 6 Sampling and Analysis Plan Addendum 2”, Liquid Waste Operations, Closure Project Engineering, October (2011).

SRR-LWE-2011-00245, Revision 2, J.L., Clark, “Tank 6 Final Volume Determination and Uncertainty Estimate”, Interoffice Memorandum, Savannah River Remediation, Savannah River Site, Aiken, SC, June (2012).

SRR-LWE-2012-00102, Revision 0, R. O. Voegtlen, “Tanks 5 and 6 Internal Equipment Evaluation”, Closure Project Engineering, Savannah River Remediation, LLC, June (2012).

U-ESR-F-00048, Revision 0, J.L., Clark, “Tank 5 Final Volume Determination and Uncertainty Estimate Report”, DOE Savannah River Site, Aiken, SC, Rev. 0, April (2011).