November 6, 2015

MEMORANDUM TO: Douglas Mandeville, Acting Chief
Low Level Waste Branch
Division of Decommissioning, Uranium Recovery, and Waste Programs

THRU: Christepher McKenney, Chief ***/RA/***
Performance Assessment Branch
Division of Decommissioning, Uranium Recovery, and Waste Programs

FROM: Cynthia Barr, Sr. Systems Performance Analyst ***/RA/***
Performance Assessment Branch
Division of Decommissioning, Uranium Recovery, and Waste Programs

Leah Parks, Systems Performance Analyst ***/RA/***
Performance Assessment Branch
Division of Decommissioning, Uranium Recovery, and Waste Programs

SUBJECT: TECHNICAL REVIEW OF FINAL INVENTORY DOCUMENTATION FOR TANK 16H at SAVANNAH RIVER SITE (DOCKET NO. PROJ0734)

The U.S. Nuclear Regulatory Commission (NRC) staff has performed a technical review of several documents prepared by the U.S. Department of Energy (DOE) that detail development of the final inventory for Tank 16H at Savannah River Site, South Carolina. This technical review supports Monitoring Factor 1.1 “Final Inventory and Risk Estimates”, 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 SRS Tank Farm Facilities (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15238B403).

As a result of the review of several DOE documents related to the development of the final Tank 16H inventory, the NRC staff concludes that the DOE has appropriately applied the concepts and methods listed in the DOE’s sampling and analysis program plan (SRR-CWDA-2011-00050, Revision 2) and quality assurance program plan (SRR-CWDA-2011-00117, Revision 0).

CONTACTS: Cynthia Barr, NMSS/DUWP
(301) 415-4015

Leah Parks, NMSS/DUWP
(301) 415-0352

To reach this conclusion, the NRC staff focused on a number of areas listed in the Tank 5 and 6 Inventory Technical Review Report (ITRR) and SRS Tank Farms Monitoring Plan (ML13085A291 and ML15238B403) related to Monitoring Factors 1.2, "Residual Waste Sampling," and 1.3 "Residual Waste Volume." Given the low residual volume in the Tank 16H primary, NRC staff's review focused on development of the annular inventory, which was deemed by the NRC staff to be more risk-significant. Many of the Tanks 5 and 6 ITRR comments, also listed in the SRS Tank Farms Monitoring Plan, could be extended to development of the Tank 16H annular inventory and are discussed in detail in the enclosed report.

With respect to waste sampling (Monitoring Factor 1.2), the NRC staff finds the DOE's proposed methodology to develop final inventory estimates for Tank Farm tanks acceptable. The NRC also finds the implementation of the sampling and analysis approach for Tank 16H adequate for use in H-Tank Farm performance assessment calculations, although several areas of potential improvement are noted, particularly related to collection of representative samples, and consideration of uncertainty in the sampled concentrations. To reach this conclusion, the NRC staff extensively reviewed the DOE inventory documentation and independently evaluated a subset of the Tank 16H analytical data to calculate the 95th percent upper confidence level for the mean.

With respect to volume estimation (Monitoring Factor 1.3), the NRC finds the DOE's proposed methodology to develop volume estimates for the Tank Farms generally acceptable. The NRC also finds the implementation of the volume estimation approach for Tank 16H generally adequate for use in H-Tank Farm performance assessment calculations. Nonetheless, the NRC continues to recommend that the DOE improve documentation of its approach, as well as validate methods used to estimate the residual volumes whether through sampling, measurement or through more qualitative methods (e.g., visual evidence). The annulus presents unique challenges with respect to volume estimation not previously reviewed by the NRC staff. Therefore, the NRC staff's review and conclusions are focused in this area.

Concentrations and volume are linearly related to inventory and in many cases, inventory is linearly related to dose. Therefore, the development of waste concentrations and volume, and consideration of uncertainty in waste concentrations and volume estimates is considered risk-significant. With respect to Tank 16H, the uncertainty associated with the final inventory is expected to be less than an order of magnitude, and closer to a factor of 2 and is therefore, considered to be of moderate to low risk-significance. Because not all of the technical issues identified in the NRC staff's SRS Tank Farms Monitoring Plan with respect to waste sampling and volume estimation have been addressed, Monitoring Factors 1.2, and 1.3 will remain open at this time. The NRC staff will monitor progress on these technical concerns as tank farm closure progresses. When the NRC staff determines that the technical concerns have been addressed, the 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 SRS Tank Farms high-level waste tanks, the NRC staff will perform a more cursory review of final inventory development under Monitoring Factor 1.1 “Final Inventory and Risk Estimates.”

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Technical Review of Final Inventory
Documentation for Tank 16H

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OFFICE	DUWP	DUWP	DUWP	DUWP	DUWP	DUWP
NAME	C. Barr	L. Parks	T. Moon	J. Shaffner	C. McKenney	C. Barr
DATE	10/28/15	10/29/15	10/ 29 /15	10/ 29 /15	11/ 05 /15	11/ 06 /15

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Technical Review of Final Inventory Documentation Supporting Tank 16H Closure

Date: October 28, 2015

Reviewers:

Cynthia Barr, Sr. Systems Performance Analyst,
U.S. Nuclear Regulatory Commission

Leah Parks, Systems Performance Analyst,
U.S. Nuclear Regulatory Commission

Programmatic Documents Previously Reviewed (see ML13085A291):

1. SRR-CWDA-2011-00050, Revision 2, "Liquid Waste Tank Residuals Sampling and Analysis Program Plan," Savannah River Remediation, LLC, Closure and Waste Disposal Authority, Aiken, SC, July 2013.[1]

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).

The Tanks 5 and 6 Inventory Technical Review Report (ML13085A291) provides a summary of these key programmatic documents. Please consult that technical review report for additional information.

Tank 16H Key Inventory Documents Reviewed:

1. SRR-CWDA-2014-00071, "Tank 16 Inventory Determination," Savannah River Site, Aiken, SC, Rev. 0, October 23, 2014.

2. SRR-LWE-2012-00224, Bhatt, P.N., "Tank 16 Primary Tank Preliminary Mapping," Savannah River Site, Aiken, SC, Rev. 0, January 10, 2013.

3. SRR-LWE-2013-00010, Clark, J.L., "Tank 16 Annulus Waste Volume Determination," Savannah River Site, Aiken, SC, Rev. 0, January 15, 2013.

4. SRR-LWE-2012-00039, Clark, D.J., "Estimation of Waste Material in the Tank 16 Annulus Following Sampling in November 2011," Savannah River Site, Aiken, SC, Rev. 0, February 28, 2012.

5. U-ESR-H-00113, Clark, J.L., "Tank 16 Final Residual Solids Determination and Uncertainty Estimate", Savannah River Site, Aiken, SC, Rev. 1, November 2013.

[1] A previous version of this report (Rev. 1) was reviewed in the Tanks 5 and 6 Inventory Technical Review Report (ML13085A291).

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6. SRR-LWE-2013-00057, “Tank 16 Sampling and Analysis Plan,” Savannah River Site, Aiken, SC, Rev. 2, July 2014.

7. SRR-CWDA-2014-00090, “Tank 16 Final Characterization Data Quality Assessment,” Savannah River Site, Aiken, SC, Rev. 1, October 23, 2014.

8. SRR-CWDA-2010-00023, “H-Area Tank Farm Closure Inventory for Use in Performance Assessment Modeling,” Savannah River Site, Aiken, SC, Rev. 4, November 11, 2014.

9. SRNL-STI-2014-00321, “Tank 16H Residual Sample Analysis Report,” L. N. Oji; D. P. Diprete; C. J. Coleman; M. S. Hay; and, E. P. Shine, Savannah River National Laboratory, Aiken, SC, October 2014.

SRR-CWDA-2014-00071, “Tank 16 Inventory Determination”, Rev. 0, October 23, 2014

SRR-CWDA-2014-00071 summarizes the development of the inventory for Tank 16H and cites several references used to support the inventory development. The sample plan SRR-LWE-2013-00057 provides information on the number and location of samples. Uncertainty in volume is addressed using a volume proportional 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-2014-00321. 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. The U.S. Department of Energy (DOE) estimated that 1.2 m^3 (330 gal) of residual waste remained in Tank 16H primary tank, and 7.1 m^3 (1910 gal) remained in the annulus following waste retrieval. The DOE provides an upper and lower estimate of the residual waste volume in the primary tank 5of 2.5 m^3 (660 gal) and 0.8 m^3 (220 gal) respectively. The DOE also provides an upper and lower estimate of the residual waste volume in the annulus of 8.0 m^3 (2,110 gal) and 6.1 m^3 (1,610 gal) respectively.

The inventory on the cooling coil and tank wall surface was determined to be insignificant based on photographic and video surveillance. Also, the Tank 16H cleaning history was similar to Tank 5F, and Tank 5F cooling coil and wall surface inventories calculated using the analytical results were determined to be insignificant. Therefore, the DOE did not sample the interior tank walls or cooling coils. A residual waste volume of 0.1 m^3 (26.3 gal) was estimated to be associated with abandoned tank equipment (SRR-LWE-2014-00017). The concentration of the equipment waste was assumed to be the same as the residual floor concentrations.

The tank floor and the annulus inventory was calculated based on the product of the waste concentration (either the primary tank or annulus), volume, density (wet) and solids content (weight percentage). The 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. The 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.

SRR-LWE-2012-00224, Bhatt, P.N., "Tank 16H Primary Tank Preliminary Mapping"

SRR-LWE-2012-00224 provides information regarding the final volume estimates for the Tank 16H primary tank. The results of the report were used to inform the sampling plan for the primary tank. In January 2011, the DOE took high-definition photographs from three locations in 4 risers for a total of 12 composite photos. Tank internals such as cooling coils, columns, supports, and tank pumps were used as landmarks to reference tank floor area. Landmarks such as tank welds, distance to the bottom of the cooling coils, and support plates were used to estimate material height. The DOE created a gridded spreadsheet of the tank floor, where each 1 ft x 1 ft (0.3 m x 0.3 m) grid section was assigned a height to estimate total volume. This report estimated that approximately 1.2 m^3 (300 gal) of residual waste remained in Tank 16H primary tank.

SRR-LWE-2013-00010, Clark, J.L., "Tank 16 Annulus Waste Volume Determination" and SRR-LWE-2012-00039, Clark, D.J., "Estimation of Waste Material in the Tank 16 Annulus Following Sampling in November 2011"

SRR-LWE-2013-00010 and SRR-LWE-2012-00039 provide information regarding the volume estimates for the Tank 16H annulus in 2012 (known as the 2012 estimate). The documents provide identical information, except SRR-LWE-2013-00010 also contains the spreadsheet calculations. In 2011, the DOE collected samples of the annulus waste under the North, South, East, and West annulus risers. The measured waste depth measurements were used to assign waste heights at the measurement locations. Photographic views of the annulus were also used in areas between the risers. Still, there were many areas of the annulus (and duct) where visual determination was not possible, and for those areas, the DOE extrapolated the height using visual or measured data from the closest areas. These reports estimate the volume in the annulus to be 12.5 m^3 (3,300 gal). The DOE did not provide uncertainty bounds on this 2012 estimate.

U-ESR-H-00113, Clark, J.L., "Tank 16 Final Residual Solids Determination and Uncertainty Estimate"

U-ESR-H-00113 summarizes the final residual solids determination and uncertainty estimate of the Tank 16H primary tank and annulus. In May 2013, the DOE deployed robotic crawlers in Risers 3 and 6 to obtain waste characterization samples and record close-up video of the primary tank floor. The revised volume estimate for the primary tank using the crawler data is 1.2 m^3 (330 gal). For the annulus, the DOE collected a total of eleven new samples from different locations inside and outside the ductwork of the annulus to support characterization. During the sampling, the DOE measured the waste depth at each of those locations in the annulus. The DOE interpolated the heights between the sample locations to estimate the material height in other areas. The DOE also collected additional photographs and video footage using a high resolution camera which provided improved images when compared to the photographs used to support the volume estimate in SRR-LWE-2013-00010. Due to the amount of reliable data available, the methodology for the 2013 volume estimate shifted from a largely visual interpretation of solids heights to the use of measured heights. The photographs were not relied upon as heavily as the measured values, but rather used to corroborate the measured and interpolated values. The revised estimate for the volume in the annulus is 7.2m^3 (1,900 gal).

The DOE considered the uncertainty in the tank floor estimate to be small given the number of landmarks within the Type II tanks. Since the cooling coil array and construction details are well-known, the DOE indicates that the uncertainty with transcribing the volume depth from the visual evidence to the map and spreadsheet is small. High-end and low-end estimates were determined by the mapping team also using judgment aided by these landmarks. The DOE states that the uncertainty in the annulus volume is also small. The DOE describes the method for measuring the depth of the waste using the auger as a precise method. The DOE determined the depth of the solids layer by lowering an auger to the top of the solids layer and marking the shaft of the auger. The DOE then lowered the auger through the solids layer and the shaft marked again, with the difference in the initial and final marks indicated the depth of the solids layers.

With regard to the volume estimation of the material in the annulus, the NRC staff provided several detailed comments related to: (1) the sampling method used to determine material heights; (2) the use of photographic evidence and landmarks to assign material heights; and, (3) interpolation method used to assign material heights in areas where no sample or visual observation are available. The DOE provided more information on the measuring method in their response to the NRC comments on the Closure Module (U-ESR-H-00128). The DOE operators indicated that it was apparent when the auger contacted the solids because the shaft was no longer hanging freely in space. The DOE stated that marking and measuring vertical position on the column of the drill rig is simple and accurate. The DOE also discussed the material irregularities and explained that uncertainty created by the surface irregularities is expected to be relatively insignificant and encapsulated in the overall uncertainty. The DOE explained that there was no more uncertainty in measuring heights within the duct versus outside the duct because visual observation was still available. The NRC staff also pointed out apparent inconsistencies between the measured height and the visual evidence in the photographs using landmarks. The DOE explained that the visual evidence is influenced by depth perception, shadows and poor lighting, and that in those cases of inconsistency, the photographs did not compel a change in the measured estimate. The DOE also explained that current volume estimation methodology does not include assigning different uncertainties to different tank areas based on method of observation. An overall uncertainty of +/- 0.5 inches is assigned at each location regardless of whether it was measured or interpolated.

SRR-LWE-2013-00057, Revision 2, “Tank 16 Sampling and Analysis Plan”

The Tank 16H sampling and analysis plan contains information on the number and locations of samples, sampling tools to be used, quantity of sample, etc. The DOE did not sample the primary tank wall or cooling coils in Tank 16H because the Tank 5 residual inventory on the primary wall and cooling coils was estimated to be orders of magnitude less than that of the floor and annulus inventory, and both tanks had been similarly washed with deionized water and oxalic acid. The DOE evaluated various sampling options and decided that, for the annulus material, the DOE would collect material from fifteen sample locations to create three composite samples for analysis was the preferred option. For the tank primary liner, the DOE decided that material from three locations would be collected and analyzed as discrete samples. In the event insufficient material is recovered from the three initial sampling locations, two additional sample locations were selected.

Because the final volume determination for the annulus was lower than anticipated (7.2 m^3 versus 12.5 m^3 (1900 versus 3300 gallons)), DOE indicates in the revision log that two of the samples in the annulus compositing arrays were shifted from the original plan to represent any heterogeneity as completely as possible in the resultant analytical samples. Revision 2 also presents an updated compositing table, revised compositing scheme (Table RL-1), and sampling array figure (Figure RL-1). Table 3.3-6 provides information on the relative volumes of each of three strata (with old volumes in strike-out), as well as a description of each of the strata.

Following the volume-proportional compositing sample approach, the composite sample creation requires the sample densities and the final annulus volume determination (and uncertainty estimate) in order to calculate the proportions of each individual annulus sample used for compositing. The final volumes and sample material densities measured in the laboratory were used to calculate the final analytical sample compositing instructions as described in the LWTRSAPP.

The Plan provides instructions on the collection of samples, as well as information on the list of radionuclides to be analyzed and the target detection limits. If an insufficient quantity of sample is taken from any location, the Plan provides instructions and contingency plans to help ensure the quality of data collected.

Section 3.4 of the Plan also provides information on the sampling equipment and materials. Samples inside the tank were collected with either a robotic sample crawler equipped with a gripper arm capable of holding a vacuum, or a vacuum attached to a pole. To collect samples from the annulus, a machine tool system consisting of a drill press, drill mast shaft, and end effector (hole saw or boring bit) was used. Samples taken outside of the duct were taken from the gap between the duct and primary liner to allow for full penetration of the material by the boring bit. After residual material is broken up by the boring bit, a labeled vacuum was lowered using a pole to collect the sample. When necessary, a hole saw end effector was used to cut through the top of the duct to access the duct interior.

SRR-CWDA-2014-00090, “Tank 16 Final Characterization Data Quality Assessment”

Tank 16H sample analysis results are provided in this report. Composite sampling is used in developing the inventory for the annulus; discrete sampling is used in developing the inventory for the primary liner (or tank) due to the low volume of residual waste in tank (insufficient material to take minimum of 15 samples). Composite sampling is 5 samples in 3 arrays, the 3 arrays comprise the composite samples. The report concludes that Tank 16H samples were collected in accordance with the revised sampling plans. Tank sample 2-P was significantly different than the other two primary tank samples and the tank samples showed variability. However, most results were below the minimum detectable concentration. The three composite samples taken from the annulus appear to be uniform with minor statistical differences. DOE contractors concluded that data are sufficient for the purpose of characterizing the waste and determination of the Tank 16H inventory.

SRR-CWDA-2010-00023, "H-Area Tank Farm Closure Inventory for Use in Performance Assessment Modeling"

A summary of this document is provided in the Tank 16H Special Analysis technical review report that will be issued concurrently with this technical review report. Please see that report for additional information.

SRNL-STI-2014-00321, "Tank 16H Residual Sample Analysis Report"

The Tank 16H Residual Sample Analysis Report provides information about Tank 16H sampling activities following waste retrieval operations, including statistical analysis of the analytical results. DOE contractors collected three samples from the primary liner (or tank) and fifteen[2] samples from the annulus. Due to the low volume of waste remaining in the tank, discrete samples were taken from the tank (i.e., the samples taken from the tank were not composited). The tank samples were dry enough and did not require extra air-drying inside the shielded cells. The samples were ground with a mortar and pestle and passed through a 850 micron sieve (mesh 20). A fraction of sample 2-P collected from the primary liner (tank) could not be ground fine enough to pass through a 850 micron sieve. This iron-rich fraction was digested and analyzed separately for Cs-137, gross alpha/beta, and elemental analysis by Inductively Coupled Plasma-Atomic Emission Spectroscopy. The analysis results revealed that the iron-rich fraction of Sample 2-P was similar in chemical composition to the remaining fraction. Figure 2 in SRNL-STI-2014-00321 illustrates sampling locations (note that samples 4P and 5P were not collected).

Eleven samples were collected from the annulus in 2013 using modified, commercially available vacuum cleaners. Sample locations are illustrated in Figure 2 in SRNL-STI-2014-00321. Some annular samples were wet and required air-drying in the shielded cell prior to analysis, and some samples could not be initially collected. An insufficient volume of sample was initially collected from two locations, 6-A and 8-A. The locations were resampled and the collected samples named 6-AR and 8-AR. Four samples collected from 2011 were combined with the eleven samples collected in 2013, to create three composite samples representing the annular inventory. Similar to the tank samples, the waste was ground with a mortar and pestle fine enough to pass through a mesh 20 sieve. Table 6 provides information on the weights of individual samples comprising the three composites. While Table 6 provides information on the weight percentage of the samples composited, limited details are provided in this report on the three groups or "strata"[3] used to represent the annular waste.

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[2] Four samples were collected in 2011. The remaining 11 samples were collected between August 2013 and November 2013.

[3] Strata differentiate residual tank or annular waste by region, or by physical or chemical differences. The composite sampling approach employed by DOE assumes three strata are present in the Tank 16H annulus. Final inventory development is based on a volume proportional compositing technique in which the relative volumes of the strata determine the weights of samples submitted for compositing. Details on the relative volumes of the strata is provided in SRR-CWDA-2010-00023, Revision 2, Table 3.3-6. SRR-CWDA-2013-00018 provides information on the locations of the strata. Material in Stations 5+00 to 23+00 comprises what is described as the "Northern" strata, and the remaining Stations comprise the "Southern" strata (see Figure 2.1-1 in SRR-CWDA-2013-00018 for delineation of annulus Stations).

While target detection limits were not always met, particularly for non-routing radionuclides, the DOE contractor reviewed all of the cases where the detection limits were not met and determined that the impacts were acceptably low. The target detection limits for routine radionuclides were met most of the time. DOE performed a statistical analysis of the sampling results. For analytes that were not detected or only a single sample was detected the smallest and largest minimum detectable concentrations (MDCs) were reported. The DOE summarized the inventory distributions (mean, standard deviation, and 95% upper confidence limit (UCL 95) for the mean concentration) for analytes with measurements on at least 2 of the 3 samples or composites.

NRC Staff Evaluation:

Sampling and Analysis

The NRC finds the sampling and analysis methodology presented by the DOE in the Liquid Waste Tank Residual Sampling and Analysis Program Plan to be generally adequate. The NRC also finds sampling and analysis of Tank 16H residual solid waste adequate for the purposes of performance assessment calculations. A number of technical issues were identified during the review and are presented below for the DOE's future consideration.

Because the Tank 16H annular inventory is considered by the NRC staff to be more risk-significant compared to the inventory remaining in the primary liner, the focus of the NRC staff's review is on the annular inventory. An early estimate of residual material remaining in the Tank 16H annulus was approximately 18 m^3 (4,700 gal). In 2006-2007, the DOE collected three samples from the annulus: (1) one sample at location IP-118; and, (2) two samples at location IP-35 (one from inside the dehumidification duct and one from outside the duct)[4]. The results from outside the dehumidification duct at IP−35 show a large fraction of the sample to be soluble in water (45-65 wt%); however, the sample from inside the duct was even more soluble in water (60-70 wt%). The amount of soluble sodium salts in sample IP-118 (25-25 wt%) appeared to be much lower than the two IP-35 samples (WSRC-STI-2008-00203, Rev. 0).

As indicated in WSRC-STI-2008-00203, Revision 0, the Tank 16H annular waste can be grouped into three distinct regions in terms of characteristics of the waste. The first region (3.78 m^3 [1,000 gal]) lies on the annulus floor in the north near IP-118. The DOE believes this region has been chemically altered due to the addition of silica from sandblasting that was conducted for leak inspections and due to high heat from steam jets that were used for a previous cleaning campaign. The combination of the addition of silica, a high pH, and high heat is believed to have chemically altered the residual material leading to the formation of alumina-silicates that DOE believes combined with the radionuclides in the residual material to reduce their solubility. The second region (2 m^3 [500 gal]) is on the annulus floor in the south near IP-35. This second region has also been chemically altered due to the introduction of sand, but less so than the north area. A third region of annular material (1.5 m^3 [410 gal]) resides within the annulus ventilation duct. The DOE expects the contamination within the ventilation duct to be more soluble because it did not contain significant amounts of silica from sandblasting. On the other hand, the Tank 16H Sampling and Analysis Plan (SRR-LWE-2013-00057, Revision 2) indicates that the material in the Annulus to the North has less sodium aluminum silicate content than the material to the South. It appears that the table in the Sampling and Analysis Plan has a typo or

[4] See Table 3-15 in NRC staff's TER (ML14094A496) for sample locations.

is otherwise incorrect. Regardless, if material in the different strata have significantly different concentrations and variability, then the relative volumes of the strata that form the basis of the volumetric proportional compositing scheme are important to ensure that representative samples are collected and composited to develop the Tank 16H annular inventory. The DOE documentation was not transparent on how DOE determined what waste material was associated with the strata that had more sodium aluminum silicate content and which strata had less. Because portions of the annulus were not sampled, a clear line of demarcation would be difficult to make. Furthermore, WSRC-STI-2008-00203, Revision 0, indicates that there is vertical heterogeneity in waste material sampled from a mound in the northern portion of the annulus (near sample IP-118), and concludes that the waste material in the annulus has a wide range of compositions at different locations:

> *The IP-118 sample also shows a small difference in composition from the top to the bottom of the sample. The bottom section of the sample appears to contain more water soluble material than the top based on the XRD data. This aspect of the sample again seems reasonable since the material at the bottom of the annulus would also be less accessible to the washing/waste removal conducted in the annulus. The samples from outside the dehumidification duct at two locations in the annulus show very different compositions and estimated solubility in water. This indicates the waste material in Tank 16H annulus may have a wide range of compositions at different locations.* WSRC-STI-2008-00203, Revision 0.

In addition to the uncertainty in the delineation of the northern and southern strata in the Tank 16H annulus, the DOE did not appear to have sufficient information on the relative volumes of waste in the three strata that it selected to represent the annular inventory at the time of sampling. The 2011 volume estimate of 12.5 m^3 (3,300 gal) was initially used to select sample locations and to assign initial weights for the samples using the volume proportional compositing approach. However, more recently the DOE revised the Tank 16H annular volume estimate lower to 7.2 m^3 (1,900 gal). The DOE was unable to make timely revisions to its sampling design to align with the significantly revised volume estimate, because data used to develop final volume estimates were collected at the same time the waste samples were collected for analysis. Although the weights of the individual samples that were composited appear to have been revised based on the final volume estimates (see Table 6 in SRNL-STI-2014-00321), the number of samples taken from each strata may have been significantly different had the final volume estimates been available at the time of sampling. In fact, the combined volume of material in the duct and southern stratum relative to the quantity of material in the northern stratum was significantly overestimated based on the 2011 volume estimate. Therefore, the number of samples taken from the northern stratum is lower than the number of samples expected based on the relative volumes of the waste materials in the annulus (e.g., over half the final estimated volume is in the northern stratum but only six of fifteen samples are taken from the northern stratum and the same number of samples, six, are taken from the duct that only constitutes little over 20 percent of the revised volume estimate for the Tank 16H annulus). The NRC staff also noted in the Tanks 5 and 6 Inventory TRR (ML13085A291) that the quantity and number of samples taken from each segment appeared disproportionate to the relative volume of the segment partially due to the significant uncertainty in early estimates of segment (or strata) volumes in the tanks prior to sampling and collection of additional information to refine the volume estimates. This uncertainty can have a detrimental impact on the ability of the DOE to obtain representative samples from the tanks and annuli of F-Area and H-Area Tank Farm tanks and should be addressed in the future through improved early volume estimates.

The NRC also notes that the DOE indicated that it does not have access for sampling the material in the southeast quadrant of the annulus; this inaccessibility affects the volume estimates as well as the analytical results and it is considered a significant uncertainty that should be factored into the performance assessment.

With regard to use of archived samples, the DOE provides a rationale for the acceptability of use of 2011 archived samples in SRR-CWDA-2013-00018, Revision 1. The NRC staff finds the DOE's use of 2011 archived samples appropriate given that the sample collection, transport, storage, and control documentation were compared against the LWTRSAPP Requirements and deemed acceptable [SRR-CWDA-2013-00018].

With regard to previously identified technical issues related to waste sampling and analysis, the NRC staff noted the following in the Tanks 5 and 6 ITRR (ML13085A291) conducted under Monitoring Factor 1.2 "Residual Waste Sampling" and in the updated SRS Tank Farms Monitoring Report (ML12212A192 and ML15238B403).

1. 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.

2. DOE should evaluate the option to composite samples within segments (or strata) to preserve information about segment (or strata) variance.

3. DOE should evaluate and present information on the relative contributions of various forms of uncertainty in its estimation of mean tank concentrations.

4. DOE should clarify the statistical approach used to estimate the UCL95 (e.g., treatment of all nine measurements as independent when computing the UCL95).

5. DOE should also consider how it can better assure sample representativeness by improving tank sampling designs, collection tools and instructions.

The NRC staff has no significant concerns regarding discrete sampling of residual waste within the tank, given the extensive washing and low volume of waste remaining in the Tank 16H primary liner. However, the first comment above, could be extended to consideration of historical information on leakage of waste into the annulus and operations that may have also impacted the heterogeneity of waste remaining in the Tank 16H annulus. Although this type of information was provided to a certain extent, as discussed above, the documentation could be more transparent on the selection of strata and the methods used to delineate the strata and the uncertainty in these delineations (e.g., how did the DOE differentiate material in the northern and southern strata and how did the DOE determine that the northern stratum included material in Stations 5+00 through 23+00). The DOE should continue to provide information about the distribution and expected heterogeneity of annular waste, a description of the segments or Strata and how they were selected, and information on the relative volumes and associated uncertainty in the estimated volumes of these segments or strata in future inventory documentation.

With regard to the second NRC comment listed above on intra-segment compositing, the DOE provided further explanation in the July 28-29, 2015, onsite observation visit (ML15239A612) that the bulk of the costs associated with sample analysis were related to the processing of the samples and not the actual analysis of the processed samples (i.e., analysis of nine composites would cost approximately three times the cost associated with analysis of three samples in triplicate). The costs associated with processing of additional composites to better understand intra-segment of strata variability is therefore, considered impractical by the DOE. The DOE could provide additional information regarding the break-down of costs associated with sample analysis to further support its position; however, the NRC staff agree that if the costs are three times as great as the current costs, that the resources would likely be better spent on addressing other technical issues.

The general approach laid out in the Sampling and Analysis Program Plan was followed for sampling of Tank 16H and therefore, no major changes were made to the approach used by the DOE, nor were any expected by the NRC staff at this time. Therefore, no changes were made to address the third NRC comment listed above. NRC staff notes, that the DOE statements regarding "measurement" error when evaluating variation in measured concentrations from triplicate analysis of a single composite sample, may be more accurately described as homogenization errors rather than measurement error (i.e., the error may be attributable to large variances in the segments or strata and inability to homogenously blend the composite samples, and not actually associated with measurement error).

With regard to the fourth NRC comment, DOE followed the methods laid out in the Sampling and Analysis Program Plan and no major changes were made to the statistical approach used by the DOE. The Closure Module (page 71) states, "The analytical results for the three composite samples allowed the overall uncertainty to be reflected in the confidence limits on the mean concentrations." Each composite sample was analyzed in triplicate to assess measurement uncertainty. SRNL-STI-2014-00321, Revision 1 Tank 16H Residual Sample Analysis Report, Appendix D, Section 3.0 (page 72) describes the statistical methods for calculating the mean concentration and the UCL95 for each radionuclide. Alternative approaches for summarizing the data are utilized depending on the number of measurements that are greater than the MDC. In the case that all of the measurements are above the MDC, SRNL-STI-2014-00321 (page 75) states, "If all of the concentration measurements for an analyte are above their MDC's, then the ANOVA F test can be performed, and a decision can be made to use the model in Equation (1) with the random effect if $F \geq F_{0.95,2,6} = 5.14325$, and to use the model in Equation (2) without the random effect if $F < F_{0.95,2,6} = 5.14325$." The random effect represents the sampling error which arises from spatial heterogeneity of the residual material, and sampling, sample preparation, and volumetric proportion errors. The model without the random effect (when $F < F_{0.95,2,6} = 5.14325$ treats all nine values as independent and the UCL95 is computed as shown below in Equation A:

$$UCL_{95\%} = \overline{Y}_{..} + t_{0.95,9-1df} \cdot \sqrt{\frac{s^2}{9}}.$$

Equation A

The NRC staff commented in the Tanks 5 and 6 ITRR (ML13085A291) that this approach may underestimate the 95th percent upper confidence level for the mean concentration (or UCL95). It is unclear how an ANOVA F test (testing whether the measurement/sampling error within the 3-measurements of a composite sample is negligible) would allow the DOE to treat all nine measurements as independent, when each triplicate measurement comes from a single composite sample. If, instead, the mean of each triplicate composite is used to represent that composite and those three values are used to calculate the UCL95,the UCL95 would be higher given the fewer degrees of freedom (2 degrees of freedom compared to 8). The NRC staff evaluated the impact of treating the 3 composite samples as 9 independent samples and concludes that the impact is modest. The UCL95 for the mean was calculated assuming that there were nine independent samples for only a handful of radionuclides present in the annulus of Tank 16H (Tc-99, U-235, and U-236). Calculation of the UCL95 assuming each composite analyzed in triplicate was a single, independent sample and assuming only three samples (and 2 degrees of freedom) reveals that the distributions would be broader but the impact of treating all of the measurements as independent did not have a large impact on the calculation of the UCL95 for the mean. Nonetheless, the NRC staff continues to recommend that the DOE clarify the basis for treating all nine samples as independent in future revisions to the Sampling Analysis Program Plan.

Finally, with regard to the fifth NRC comment listed above that the DOE should consider how it can better assure sample representativeness, the NRC staff noted improvements in this area. For example, the DOE included information on the methods and tools to be used to sample the Tank 16H primary and annulus in SRR-CWDA-2013-00018, Revision 1, and the DOE appears to have been successful in obtaining the targeted samples. However, the DOE was unable to initially obtain sufficient sample material at locations 6-AR and 8-AR in the annulus of Tank 16H and had to re-sample. These same two locations were discussed in SRR-CWDA-2013-00035, which indicated that two samples, both an upper and a lower sample, could be collected from the mounds at these locations (identified by the location of the inspection ports that would be used to obtain the samples, IP-118 and IP-154). It is not clear why the DOE had difficulty obtaining samples at these locations of accumulated waste material, when upper and lower samples were previously collected and characterized in WSRC-STI-2008-00293, Revision 0. Furthermore, it is not clear if the material that was eventually collected from IP-118 and IP-154 (6-AR and 8-AR) is representative of the waste in that area of the annulus given the thickness of the mounded waste and potential vertical heterogeneity, which was noted in WSRC-STI-2008-00203, Revision 0.

The DOE also indicates in the Tank 16H Sampling and Analysis Plan, SRR-LWE-2013-00057, Revision 2, that samples taken outside of the duct were taken from the gap between the duct and primary liner to allow for full penetration of the material by the boring bit. It is unclear if the material on either side of the annulus duct is homogeneous, given potential differences in residual waste material, as well as cleaning effectiveness of material on either side of the duct. In the future, the DOE should provide information to support its assumption that material on either side of the duct is homogeneous. The DOE should also continue to draw on lessons learned from previous campaigns to ensure that it is able to collect representative samples.

The NRC will also continue to monitor, as applicable, the DOE arguments related to the elimination of radionuclides from the list of constituents to be analyzed under Monitoring Factor 1.2. As the DOE continues to evaluate assumptions for the H-Tank Farm performance assessment and its inventory as a result of monitoring activities, the DOE should concurrently re-evaluate its list of highly radioactive radionuclides (HRRs) as new information that could significantly change the results of its HRR evaluation becomes available. The DOE's analytical list is broader than its HRR list, so the DOE will have assurance that it will develop inventories for other radionuclides which could potentially be risk-significant but that are not on the HRR list because they are expected to be present in such low concentrations. The NRC staff recommends that the DOE continue to examine the reasons for any unforeseen results, should they occur, and attempt to trace them back to known waste streams or processes that might reveal other radionuclides that could have been underestimated by the projections based on Waste Characterization System data. The DOE should assess, through future tank residual characterization, the validity of prior assumptions and the resulting impacts to the list of HRRs.

With regard to Monitoring Factor 1.4, "Ancillary Equipment Inventory," the DOE indicated that it still has plans to sample ancillary equipment but has not yet developed documentation to perform this activity. As documented in the NRC staff's Tank Farm Monitoring Plan, Monitoring Factor 1.4, "Ancillary Equipment Inventory," the NRC staff will monitor the DOE's efforts to verify assumptions regarding the relatively low risk of ancillary equipment through sample and analysis.

In conclusion, the NRC finds the DOE's proposed methodology to develop final inventory estimates for Tank Farm tanks acceptable. The NRC also finds the implementation of the sampling and analysis approach for Tank 16H adequate for use in H-Tank Farm performance assessment calculations, although several areas of potential improvement are noted in this report, particularly related to collection of representative samples, and consideration of uncertainty in the sampled concentrations. To reach this conclusion, the NRC staff extensively reviewed the DOE inventory documentation and independently evaluated a subset of the Tank 16H analytical data to calculate the UCL95 for the mean. For example, the NRC's independent evaluation showed that other statistical techniques (e.g., bootstrap method) would yield similar results to the DOE's results.

Volume Estimation:

The NRC finds the methods used by the DOE to develop the residual waste volumes for the Tank 16H primary liner and annulus generally adequate. However, a number of technical issues were identified during the review and are presented below for the DOE's future consideration.

Because the Tank 16H annular inventory is considered by the NRC staff to be more risk-significant compared to the inventory remaining in the primary liner, the focus of the NRC staff's review is on the annular inventory. As noted in the preceding section evaluating waste sampling, the DOE revised early (2007) estimates of 18 m^3 (4,700 gal) of residual waste remaining in the annulus to 12.5 m^3 (3,300 gal) based on visual evidence and samples taken in 2011 and analyzed in 2012. However, more recently, the DOE revised the volume estimates to 7.2 m^3 (1,900 gal). With regard to volume estimation, the NRC staff developed a number of detailed comments on the Tank 16H Closure Module related to use of photographic data in developing the annular waste volume (ML15103A413). Following the July 28-29, 2015, on-site observation, the DOE provided responses to a number of the NRC comments, primarily related to the DOE's volume estimation methods (ML15247A154). Because the NRC staff did not receive the responses until after the July 28-29, 2015, on-site observation visit, the NRC staff did not have an opportunity to review and discuss the DOE's April 2015 responses during the visit. Nonetheless, the responses were helpful in addressing a number of the NRC staff's questions on the methods used to develop the residual waste volume in the Tank 16H annulus. However, the NRC staff continues to have technical questions in some areas as noted below.

During the July 2015 on-site observation, the DOE clarified that it generally relied on measured values of waste heights to develop the annular inventory and visual evidence was used to confirm or deny the plausibility of measured values. Visual evidence was also used when interpolating solids heights between sampling locations. However, in most cases, the DOE used simple interpolation methods to assign waste heights between measured values and rarely used visual evidence to adjust heights between areas that were not measured. While the visual data appeared to be at odds with the interpolated data in some instances, the DOE's methods are reasonable and appear sound in most cases. However, in certain limited cases, the arguments do not appear to be supported. For example, the DOE indicates in U-ESR-H-00128 the following (Figure 10 referred to in the text is reproduced below for ease of reference):

> *"STA 10+00 is an area between two measured values of 2 inches and 5.5 inches. Visual evidence suggests that the solids height did not increase between the two sample locations, therefore the value at STA 10+00 would 5 inches or less. There is a minimal amount of material to the right side of the duct, material is coating the left side of the duct, then the material appears to decrease in height away from the duct to the left (Figure 10). Several data points were used to assign a value:*
>
> - *material height to the right and left*
> - *duct height for material collected on the duct*
> - *the appearance of decreasing material as the annulus continues to the west*
>
> *The interpolated height from the nearest measured heights (3 inches) was assigned for this area, and evaluation of visual evidence did not result in adjustment to the interpolated height. Visual depth perception was a factor in the decision to not adjust the interpolated height. A photo of the area is included below (Figure 10)."*
>
> Note: Figure 10 is reproduced as Figure 1 below for ease of reference.

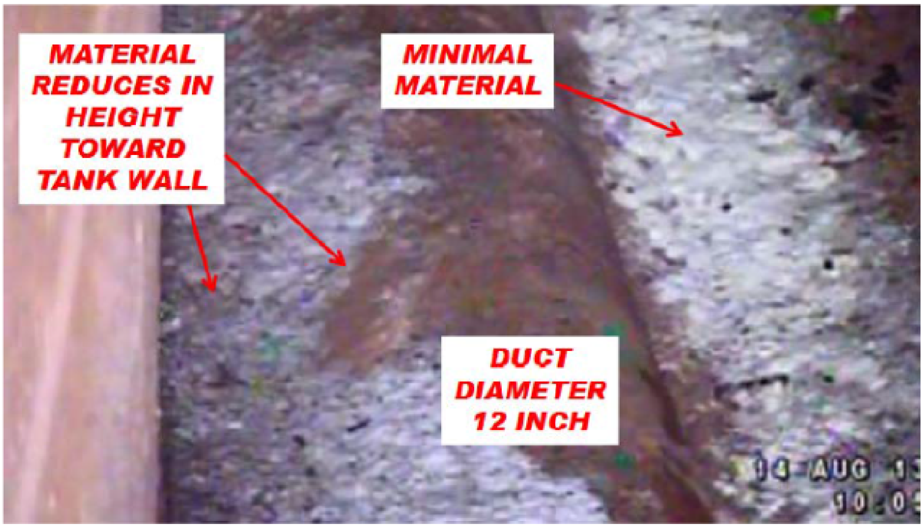

Figure 10: (Area at STA 10+00 interpolated to a height of 3 inches. Photo M U-ESR-H-00113)

Figure 1 Visual Evidence of Annular Waste Heights Near Station 10+00 (Reproduced from Figure 10 U-ESR-H-00113).

The photographic evidence clearly shows waste near the top of the annulus duct at 12 inches on the primary liner side of the duct; however, the assigned height in this area is 3 inches based primarily on interpolation between nearby measured values. While the surface along the radius varies, the DOE assigns a single height at each location. This example shows the DOE's reluctance to increase the volume based on visual evidence due to such issues as depth perception. This reluctance appears warranted if the measured values are more certain and visual evidence is less compelling. In this example, the visual evidence that waste is at the top of the known landmark on the primary liner side appears to be compelling to the NRC staff.

This example also illustrates the difficulty in use of visual evidence in assigning waste heights, an approach that is commonly used in assigning volumes in the primary liner, as discussed further below.

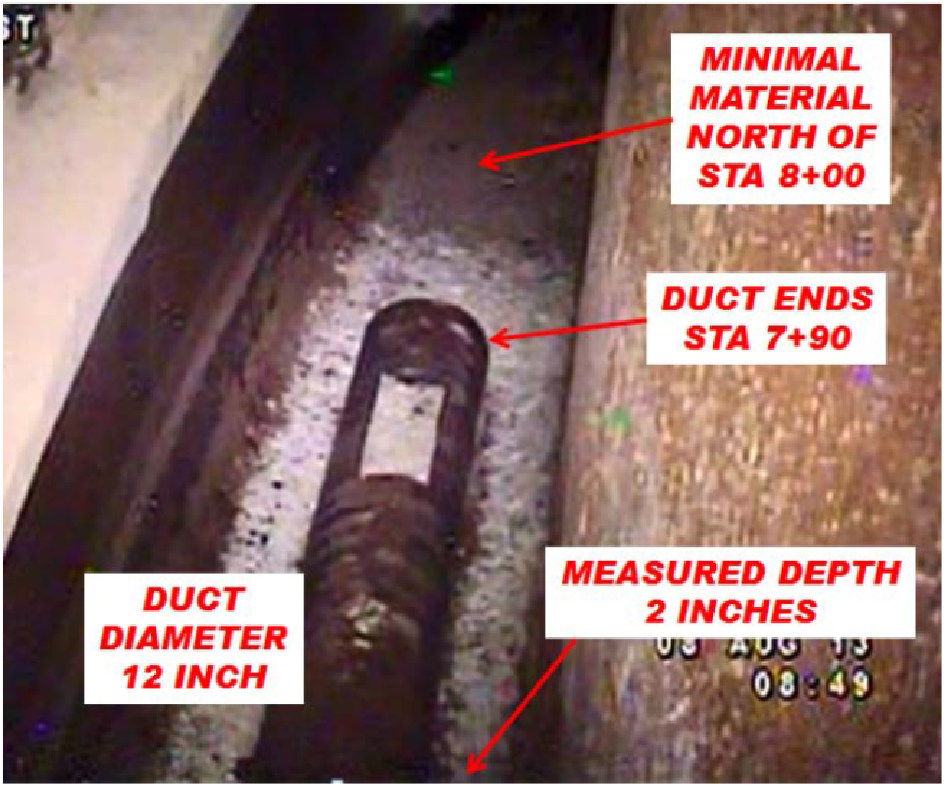

Figure 9: (Area at STA 8+00 near STA 7+00 measured at 2 inches. Photo L U-ESR-H-00113)

Figure 2 Visual Evidence of Annular Waste Heights Near Station 8+00 (Reproduced from Figure 9 in U-ESR-H-00113).

In another example, the DOE used visual evidence to adjust the waste heights lower. At Station 9+00 the depth estimate was reduced from six inches to one inch. The prior estimate was based on visual evidence and the revised estimate is a result of interpolation from 2013 measured sample heights. In response to an NRC comment questioning the Station 9+00 depth estimate reduction from six inches to one inch, the DOE indicates the following:

> *"The measured height at STA 7+00 was 2 inches in 2013. A photo of nearby area 8+00 was provided in Figure 9. There are no landmarks in the area that are close to being 2 inches tall. There is a definite change in material color. Material north of STA 8+00 appears to be minimal and reducing as it continues north. There is no evidence to suggest that 2 inches is not an accurate depth for STA 8+00. Material height at STA 9+00 was reported to be 1 inch from visual observation that indicated solids were reducing in height toward the north."*

It is unclear if the darker color waste at the top of Figure 9 is due to a thinner waste depth. The darker color could be due to poor lighting in this area. The change in color does not appear gradual, but rather abrupt as might occur with a shadow.

The accuracy of the measured values has not yet been established. The NRC staff inquired about the uncertainty in the depth measurements based on marking the shaft of the auger when the top of waste had been reached and the shaft of the auger when the bottom of the waste had been reached (ML15103A413). The DOE indicated that it was clear when the top of waste had been reached because the auger was no longer hanging in space and the auger could be felt against the hardness of the waste that was similar to "very fine aggregate" or likened to "very weak grout" (U-ESR-H-00128). The DOE also indicated that due to the consistency of the solids, the DOE did not think that the auger would penetrate the surface in any significant amount and thus indicated that there was a very small amount of uncertainty introduced by the positioning of the auger. Although it might be clear if the auger was above the waste top and hanging in space, this is not the primary concern of NRC staff as this error would lead to a conservative bias. However, the NRC staff would note that auger penetration of the waste surface before the auger shaft was marked would serve to bias the height estimates low. While arguments based on the hardness of the waste are compelling, video observation of waste sampling would help the NRC staff better understand the potential for the auger to penetrate the waste surface and potential error associated with assigning waste heights.

The NRC staff are also concerned that height estimates in the duct are more uncertain given the difficulty in sampling inside the duct. For example, if tools are used to saw a new hole in the Tank 16H annulus duct to obtain a sample, the waste near the duct surface may be inadvertently disaggregated, biasing the duct waste heights low. Similarly, if the DOE sampled in previously drilled holes in the duct where waste had already been disturbed and/or sampled, then the height estimates may also be biased low. The DOE should address this concern in future discussions with the NRC staff and in future inventory documentation.

The NRC staff would also note that selection of measurement location may bias the volumes estimates high or low if the topography is rough, or trends toward thicker or thinner waste heights along the radius. While the DOE indicated that the waste heights were generally even (U-ESR-H-00128), the response is not strongly supported by the visual evidence. For example, the DOE concluded that the waste at Station 10 (see Figure 1) on one side of the duct was near the duct height of 12 inches and dropped off, and was lower on other side of the duct leading to an average waste height of 3 inches. Additionally, there is clear evidence of radial heterogeneity in photographs taken of the annulus. For example, the material in the annulus on the outside of the duct closer to the tank wall appears to be a lower height than that on the other side (e.g., see pages 16, 17, 18, and 20 in SRR-LWE-2013-00027 that appear to show significant differences in material heights on either side of the duct). Because the Sampling and Analysis Plan (SRR-LWE-2013-00057, Revision 2, page 30) indicates that samples were taken on the side closer to the tank wall, if this is true[5], then the volume estimates could be biased low. If found to be significant, the DOE should consider variability in heights across the radius of the annulus, and incorporate this into the volume estimate. The DOE should consider mapping the annulus into sections when consistent radial variability is present and documenting the approach used, as opposed to assuming a consistent height on either side of the duct at each location with mappers making manual interpolations with minimal documentation available for public inspection.

[5] SRR-LWE-2013-00057, Revision 2, states the following: "To collect samples outside the dehumidification duct, the pipe will be placed on the residual material in the gap between the duct and primary liner. This should allow for full penetration of the material by the boring bit." However, it is not clear from SRR-LWE-2013-00027 that all of the samples were taken from the tank wall side of the annulus duct.

Figure 3 Photograph of Waste Near Sample 2-A (Reproduced from Figure in Section 4.7 of SRR-LWE-2013-00027, page 16).

The NRC staff identified technical issues related to volume estimates in a previous technical review report (i.e., Tanks 5 and 6 ITRR [ML13085A291]) conducted under Monitoring Factor 1.3 "Residual Waste Volume" (ML12212A192 and ML15238B403). These technical issues include the following:

1. The DOE should better understand the accuracy of mapping team height estimates through additional field validation activities for a range of solid material heights.

2. The 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, the DOE should clarify how it represents uncertainty in the assignment of high-end 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).

3. The 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).

4. The DOE should be more transparent with respect to its approach to: (1) mapping annular volumes including use of a crawler to inspect internal surfaces; and, (2)

estimating residual waste volumes in ventilation ducts. The DOE should consider uncertainty in annulus volume estimates.

With regard to the fist NRC comment regarding validation of assigned waste heights, this comment could be extended to estimation of waste heights in the annulus. If one assumes that the measured or sampled heights are accurate, then one could argue that the sampled heights do not validate well the visually determined heights because the measured heights varied rather significantly from the visually assigned heights. However, the accuracy of the measured heights has not yet been established. The DOE should provide additional information to better understand the accuracy of measured heights that will allow for proper consideration of uncertainty (e.g., video showing the process used to measure the waste height in the annulus to confirm to what accuracy the operators are able to mark the shaft of the auger when the top of the waste is reached or through use of another direct sampling technique).

With regard to the second NRC comment related to uncertainty associated with resolution of height estimates, the comment could be extended to development of the inventory in the annulus. For example, the assignment of height based on a single, discrete measurement and interpolation of these discrete measurements over large areas in the annulus where the waste height is not homogeneous or not visible introduces uncertainty in the volume estimation approach. Likewise, it is not clear that the DOE's assignment of +/- 0.5 inches for the uncertainty waste height in the annulus is well supported. This value may be associated with the uncertainty in the marking of the auger shaft but the uncertainty in marking the waste surface from the low side has not yet been established and the uncertainty in marking the shaft from the high and low side is likely not congruent. It is expected that in most cases, it would be clear to the DOE when the bottom of the duct or annulus had been reached leading to less uncertainty in marking the shaft when the bottom had been reached, but that any uncertainty would likely bias the height estimate low (i.e., marking the shaft before the bottom had been reached).

With regard to the third NRC comment that the 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), the DOE's interpolation approach for waste heights in the annulus could be better supported, and possibly improved. However, the NRC staff is unaware of any documentation that provided information on how the mappers manually interpolated heights across the radius of the annulus in cases where the heights were radially variable, and therefore, other than reviewing point, interpolation methods along the circumference of the annulus provided in U-ESR-H-00113, the NRC staff did not evaluate any other information in this area. Given the lower risk-significance of the inventory in the primary liner of Tank 16H, this comment, which is more applicable to development of the inventory for the waste located inside the primary liner, was not a focus of this review.

With regard to the fourth NRC comment related to transparency with respect to annular inventory development and consideration of annular inventory uncertainty, this technical review report is focused in this area and several new technical issues have been identified as discussed in the previous text.

With regard to the cooling coil inventory, the DOE's rationale for determining when cooling coils will be treated and determining when an inventory for cooling coils (and internal tank surfaces) will be developed is unclear. The rationale for assuming no inventory on tank internal surfaces or cooling coils for Tank 16H is that the Tank 16H cleaning history is similar to Tank 5F, and the visual evidence did not show any significant material. While the DOE's arguments with respect to Tank 16H appear reasonable, the DOE indicated in the July 28-29, 2015, on-site observation visit that the cooling coils were water washed in Tanks 5F and 6F and walls were spray washed with water in Tanks 18F and 19F, but the DOE believed that water washing would not significantly remove waste from the cooling coils in Tank 12H (ML15239A628). During the on-site observation meeting, the DOE also stated that it did not expect there to be residue on Tank 12H cooling coils, which resembled "barnacles." However, Tank 12H did, in fact, have significant build-up of waste on the cooling coils (ML15244A839). These statements appear at odds with previous DOE statements that indicated: (1) that use of oxalic acid would remove build-up from cooling coils, and (2) that visual evidence is sufficient to conclude that there is no significant build-up of radioactivity on the cooling coils. The NRC staff will clarify with the DOE in a future teleconference or onsite observation when and how it determines whether there is a significant inventory on the cooling coils, and whether cooling coil washing with water or oxalic acid will be conducted to remove potential build-up on cooling coils and other internal tank surfaces.

In conclusion, the NRC finds the DOE's proposed methodology to develop volume estimates for the Tank Farms generally acceptable. The NRC also finds the implementation of the volume estimation approach for Tank 16H generally adequate for use in H-Tank Farm performance assessment calculations. Nonetheless, the NRC continues to recommend that the DOE improve documentation of its approach, as well as validate methods used to estimate the residual volumes whether through sampling, measurement or through more qualitative methods (e.g., visual evidence). The annulus presents unique challenges with respect to volume estimation not previously reviewed by NRC staff. Therefore, the NRC staff's review and conclusions are focused in this area.

The DOE should also consider improvements to its consideration of waste volume uncertainty. Alternatively, the DOE could more clearly document how it has managed volume uncertainty with conservative assumptions (i.e., assumptions and methods that clearly tend to over- rather than under-estimate the residual volumes) to reduce resources spent on developing and reviewing the residual volume estimates. To reach this conclusion, the NRC staff extensively reviewed the DOE documentation for volume estimates for Tank 16H.

Teleconference or Meeting:

Tank 16H inventory development was discussed at an on-site observation held at SRS on July 28-29, 2015. The July 28-29, 2015, on-site observation report (ML15239A628) provides a summary of the on-site observation including a detailed list of the NRC questions and the DOE answers provided on Tank 16H inventory.

Follow-up Actions:

The NRC staff will continue to monitor the DOE's tank sampling and analysis program under Monitoring Factor 1.2 "Residual Waste Sampling" listed in the NRC staff's plan for monitoring the Tank Farm (ML15238B403) focusing on the technical issues listed in this review report. Most of the NRC staff's technical issues discussed in this technical review report are related to previously identified issues but focus on development of the annular inventory in Tank 16H, and in particular, the DOE's efforts to collect representative samples and consider uncertainty in sampled concentrations.

The NRC staff will also continue to monitor the DOE's tank volume estimation program under Monitoring Factor 1.3 "Residual Waste Volume" listed in the NRC staff's plan for monitoring the Tank Farm (ML15238B403) focusing on technical issues listed in this review report. Most of the NRC staff's technical issues discussed in this technical review report are related to previously identified issues but focus on development of the annular inventory in Tank 16H, and in particular, the DOE's efforts to validate annular waste height estimates and its consideration of uncertainty in volume estimates.

DOE should address the technical concerns listed in this review report, which are not explicitly identified in the NRC staff's monitoring plan, when developing inventories for the Tank Farm tanks in the future. In general, inventory is considered by the NRC staff to be of moderate risk-significance. However, the technical concerns identified by the NRC staff in this report for Tank 16H are collectively considered to be of moderate to low risk-significance based on their importance to the NRC staff's conclusions regarding Tank Farm compliance with the performance objectives in 10 CFR Part 61, Subpart C.

Open Issues:

There are no open issues associated with the DOE's program for estimating final tank inventories. Treatment of tank inventory uncertainty in the performance assessment calculations will be evaluated in a separate technical review report related to the Tanks 16H Special Analysis to be issued concurrently with this technical review report.

Conclusions:

As a result of the review of several DOE documents related to the development of the final Tank 16H inventory, the NRC staff concludes that the DOE has appropriately applied the concepts and methods listed in the DOE's sampling and analysis program plan (SRR-CWDA-2011-00050, Revision 2) and quality assurance program plan (SRR-CWDA-2011-00117, Revision 0). To reach this conclusion, the NRC staff focused on a number of areas listed in the Tank 5 and 6 ITRR and SRS Tank Farms Monitoring Plan (ML13085A291 and ML15238B403) related to Monitoring Factors 1.2, "Residual Waste Sampling," and 1.3, "Residual Waste Volume". Given the low residual volume in the Tank 16H primary, NRC staff's review focused on development of the annular inventory, which was deemed by the NRC staff to be more risk-significant. Many of the Tanks 5 and 6 ITRR comments, also listed in the SRS Tank Farms Monitoring Plan, could be extended to development of the Tank 16H annular inventory and are discussed in detail in this report.

With respect to waste sampling (Monitoring Factor 1.2), the NRC staff finds the DOE's proposed methodology to develop final inventory estimates for Tank Farm tanks acceptable. The NRC also finds the implementation of the sampling and analysis approach for Tank 16H adequate for use in H-Tank Farm performance assessment calculations, although several areas of potential improvement are noted, particularly related to collection of representative samples, and consideration of uncertainty in the sampled concentrations. To reach this conclusion, the NRC staff extensively reviewed the DOE inventory documentation and independently evaluated a subset of the Tank 16H analytical data to calculate the 95UCL for the mean.

With respect to volume estimation (Monitoring Factor 1.3), NRC finds the DOE's proposed methodology to develop volume estimates for the Tank Farms generally acceptable. NRC also finds the implementation of the volume estimation approach for Tank 16H generally adequate for use in H-Tank Farm performance assessment calculations. Nonetheless, the NRC continues to recommend that the DOE improve documentation of its approach, as well as validate methods used to estimate the residual volumes whether through sampling, measurement or through more qualitative methods (e.g., visual evidence). The annulus presents unique challenges with respect to volume estimation not previously reviewed by the NRC staff. Therefore, NRC staff's review and conclusions are focused in this area.

Concentrations and volume are linearly related to inventory and in many cases, inventory is linearly related to dose. Therefore, the development of waste concentrations and volume, and consideration of uncertainty in waste concentrations and volume estimates is considered risk-significant. With respect to Tank 16H, the uncertainty associated with the final inventory is expected to be less than an order of magnitude, and closer to a factor of two and is therefore, considered to be of moderate to low risk-significance. Not all of the technical issues identified in the NRC staff's SRS Tank Farms Monitoring Plan with respect to waste sampling and volume estimation have been addressed. Therefore, Monitoring Factors 1.2, and 1.3 will remain open at this time. The NRC staff will monitor progress on these technical concerns as tank farm closure progresses. When the NRC staff determines that the technical concerns have been addressed, the 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 SRS Tank Farms high-level waste tanks, the NRC staff will perform a more cursory review of final inventory development under Monitoring Factor 1.1 "Final Inventory and Risk Estimates."

Additional References:

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, “Technical Review of Final Inventory Documentation for Tanks 5 and 6 at F-Tank Farm, Savannah River Site, (PROJECT NO. PROJ0734)”, ML13085A291, September 30, 2013.

NRC, “NRC Staff Comments: SRR-CWDA-2013-00091, Rev. 0, Industrial Wastewater Closure Module for Liquid Waste Tank 16, H-Area Tank Farm, Savannah River Site”, ML15103A413, April 2015.

NRC, “The U.S. Nuclear Regulatory Commission July 28-29, 2015, Onsite Observation Visit Report for the Savannah River Site Combined F- and H-Tank Farm Closure”, ML15239A628, October 5, 2015.

NRC, “U.S. NRC Plan for Monitoring Disposal Actions Taken by the U.S. Department of Energy at the Savannah River Site F-Area and H-Area In Accordance with the Ronald Reagan National Defense Authorization Act for FY 2005”, ML15238B403, October 6, 2015.

SRR-CWDA-2013-00018, Revision 1, “Tank 16 Sample Location Determination Report”, Savannah River Remediation, LLC, Closure and Waste Disposal Authority, Aiken, SC, July 2014.

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