SRR-CWDA-2015-00074
Revision 0

Addendum to the *Industrial Wastewater Closure Module for Liquid Waste Tank 12H H-Area Tank Farm, Savannah River Site, SRR-CWDA-2014-00086, Revision 0, May 2015*

October 2015

Industrial Wastewater Construction Permit No. 17,424-IW

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CM	Closure Module
CMA	Closure Module Addendum
CVAA	Cold-Vapor Atomic Absorption
DCF	Dose Conversion Factor
DOE	United States Department of Energy
DQA	Data Quality Assessment
EPA	United States Environmental Protection Agency
FFA	Federal Facility Agreement
FMB	Fourmile Branch
GCP	General Closure Plan
HTF	H-Area Tank Farm
IC	Ion Chromatography
ICM	Integrated Conceptual Model
ICP-ES	Inductively Coupled Plasma-Atomic Emission Spectroscopy
LSC	Liquid Scintillation Counting
LWTRSAPP	Liquid Waste Tank Residuals Sampling and Analysis Program Plan
LWTRS-QAPP	Liquid Waste Tank Residuals Sampling – Quality Assurance Program Plan
MCL	Maximum Contaminant Level
MDC	Minimum Detectable Concentration
MOP	Member of the Public
OU	Operable Unit
PA	Performance Assessment
PRG	Preliminary Remediation Goal
QA	Quality Assurance
RCRA	Resource Conservation and Recovery Act
RFS	Removal from Service
RSL	Regional Screening Level
SA	Special Analysis
SCDHEC	South Carolina Department of Health and Environmental Control
SLDR	Sample Location Determination Report
SRNL	Savannah River National Laboratory
SRR	Savannah River Remediation LLC
SRS	Savannah River Site
TDL	Target Detection Limit
TEDE	Total Effective Dose Equivalent
TSAP	Tank-Specific Sampling and Analysis Plan
UCL95	Upper 95% Confidence Limit

EXECUTIVE SUMMARY

As explained in the Tank 12H Closure Module (CM), a two-step approach is being used to develop, review, and approve the CM and this Addendum. On August 10, 2015, the South Carolina Department of Health and Environmental Control (SCDHEC) conditionally approved the Tank 12H CM as follows:

1. *This closure module may need to be modified pending the Department's review of the Tank 12H Closure Module Addendum*.
2. *To the extent that SCDHEC has new information that has a bearing on the adequacy of closure, SCDHEC reserves the right to modify approval of this closure module in the future to address activities yet to be performed (e.g., cap installation).* [DHEC-OS-2015-08-10-01]

Coincident with the preparation and conditional approval of the CM, Tank 12H residual materials sampling and analysis has been completed. The second step of the process has been completed and the final inventory characterization information is presented in this CM Addendum (CMA) for approval by SCDHEC. The CM and CMA support the removal from service (RFS) of underground radioactive waste Tank 12H in the H-Area Tank Farm (HTF) under the *Construction Permit #17,424-IW, SRS F/H-Area, Aiken and Barnwell County* (hereinafter referred to as Construction Permit #17,424-IW). [DHEC_01-25-1993]

The United States Department of Energy (DOE) intends to remove from service Tank 12H at the Savannah River Site (SRS) in accordance with SCDHEC Regulation 61-82, *Proper Closeout of Wastewater Treatment Facilities*, and SCDHEC Regulation 61-67, *Standards for Wastewater Facility Construction*. In addition, RFS of Tank 12H by this process is intended to be consistent with the applicable requirements of the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) described in the Federal Facility Agreement (FFA), which will govern the subsequent remediation of the HTF operable unit (OU). These regulations were reviewed at the time of development of this CMA and have been verified to have had no changes since the HTF General Closure Plan (GCP) (SRR-CWDA-2011-00022) was issued. [SCDHEC R.61-82, SCDHEC R.61-67, WSRC-OS-94-42]

The CM described the processes by which DOE removed waste from Tank 12H and isolated the tank from the HTF facilities that remain operable. The CM was developed using a forecasted inventory for Tank 12H. The final characterization of residual material remaining in the waste tank has been completed, and the actual Tank 12H residuals inventory has been determined. A Tank 12H Special Analysis (SA) was performed that compared the final inventory determination with the forecasted inventory used in the CM. The final Tank 12H inventory was also used to evaluate the impacts. The Tank 12H SA also performed in-depth analyses for each contaminant that had an actual inventory higher than the forecasted inventory used in the Tank 16H SA to evaluate the impact to expected facility performance. DOE has confirmed that regulatory performance objectives will be met and that the stabilized Tank 12H would be protective of human health and the environment. The final Tank 12H inventory characterization and the applicable results from the Tank 12H SA have been documented in this CMA.

Based on the information provided in the CM, the CMA, and supporting documents, it may be concluded that (1) there is reasonable assurance that, at the time of final FFA corrective/remedial actions, groundwater concentrations derived from residual contamination in the tank and

ancillary structures will meet the HTF GCP performance objectives and (2) further waste removal is not technically practicable from an engineering perspective.

Through completion of the CM and CMA, DOE will have determined that all HTF GCP requirements have been met to proceed with removing Tank 12H from service and that DOE is ready to complete the process by stabilizing the tank with grout. Through previous conditional approval of the CM and approval of this CMA, SCDHEC is agreeing that waste removal activities for Tank 12H can cease and authorizes stabilization of the tank and the residual contaminants under Construction Permit #17,424 IW. [DHEC_01-25-1993] Following operational closure, DOE will submit a Final Configuration Report for Tank 12H to SCDHEC (as described in the HTF GCP) with certification that the RFS activities have been performed in accordance with the HTF GCP, the CM, and CMA.

1.0 INTRODUCTION

Closure Module Addendum Overview

The Tank 12H CM was prepared using preliminary residuals volume information, and an SA that used the final Tank 16H and forecasted Tank 12H residuals inventory data. Following regulatory review and public comment, conditional approval of the CM by SCDHEC was provided on August 10, 2015 and is contingent upon approval of this CMA.

Full approval of the CM and this CMA support the RFS of Tank 12H under Construction Permit #17,424-IW. This final approval would follow after submittal, review, and public comment on this Addendum to the CM presenting the updated and final information based on actual data from sampling and analysis of the residual waste.

As described in the Tank 12H CM, following completion of the residual materials characterization, the final Tank 12H residuals inventory has been determined. A Tank 12H SA has been performed to compare this final inventory determination against the forecasted inventory used in the CM. DOE has confirmed that the regulatory performance objectives continue to be met and that the stabilized Tank 12H is protective of human health and the environment. The Tank 12H characterization details, final inventory determination, and SA results are documented in this CMA.

This CMA presents the information that was either preliminary or unavailable when the CM was prepared and conditionally approved. The Tank 12H description, operational history, waste removal, assessment of deploying additional removal technology, tank isolation and stabilization, and maintenance and monitoring plans were provided in the Tank 12H CM. [SRR-CWDA-2014-00086] Table 1.0-1 summarizes the information used in the CM and the updated information presented in this CMA to support the Tank 12H RFS.

This CMA provides the conclusion that DOE has demonstrated that after evaluating the final Tank 12H characterization results, the proposed RFS configuration is protective of human health and the environment and that the closure actions will continue to be supportive of meeting the applicable performance standards for the closure of the HTF OU.

1.1 CMA Organization

The original Tank 12H CM section numbering has been retained in this CMA. However, sections of the CM that have not been updated in this CMA are noted under the section headings.

2.0 FACILITY DESCRIPTION

See the Tank 12H CM Section 2.0 (pages 14-23)

3.0 WASTE REMOVAL

See the Tank 12H CM Section 3.0 (pages 24-55)

4.0 RESIDUAL MATERIALS CHARACTERIZATION

Table 4.0-1 summarizes the differences in the information used in the Tank 12H CM development and the information updated in this CMA.

Table 4.0-1: Summary of Tank 12H Information Used in the Closure Module and Updated in the Closure Module Addendum[a]

Type of Information	Tank 12H Closure Module	Tank 12H Closure Module Addendum
Residuals Volume Determination	Included the preliminary residuals volume estimate consistent with the presentation: *Proposal to Cease Waste Removal Activities in Tank 12 and Enter Sampling and Analysis Phase,* (SRR-CWDA-2013-00125)	**Section 4.1** presents the final residuals volume determination established using additional photographs and video footage obtained during the tank sampling that augments the preliminary residuals mapping and volume estimate
Residual Materials Characterization Sampling	The final characterization sampling information was not available during the CM development. The CM was prepared using a forecasted Tank 12H inventory and not the actual residuals characterization results	**Section 4.2** discusses residual material sampling including: sampling techniques and tools, sample locations, cooling coil scale and liquid characterization, and analytical sample compositing
Derivation of Constituents of Concern and Analytes	Discussed and presented the chemical and radiological constituents of concern derived for Tank 12H analyses	**Sections 4.3.1, 4.4.1,** and **4.5.1** present the chemical and radiological analytes for the characterization of the Tank 12H cooling coil scale, liquid, and composite floor residuals samples respectively
Sample Analyses	The final sample characterization information was not available during the CM development	**Sections 4.3.2, 4.4.2,** and **4.5.3** respectively present the analytical results for the cooling coil scale, liquid, and composite floor residuals samples **Section 4.6** presents the Data Quality Assessment (DQA) discussion
Inventory Determination	The CM used a forecasted Tank 12H inventory and included a discussion of the bases used for the forecasted inventory	**Section 4.8** presents the final Tank 12H inventory determination based on the analytical results and the final residual materials volume determination
Special Analysis Results	The CM used the Tank 16H SA, which included the fate and transport modeling results using both the final Tank 16H residuals inventory and the forecasted Tank 12H residuals inventory	**Section 5.0** discusses the Tank 12H SA results concerning the predicted peak groundwater concentrations and the impact on the performance objectives when the final Tank 12H residuals inventory is used

[a] This table updates Table 4.0-1 in the Tank 12H CM

Tank 12H Residual Materials for Characterization

The Tank 12H primary tank contained three types of residual materials for sampling and characterization:

- The residual solids on the waste tank floor
- A scale material coating the upper portion of the cooling coils
- A free-liquid phase above the residual solids at the time of sampling

The annulus contains less than 25 gallons of residual solids as a result of leakage through the primary liner wall. [C-ESR-G-00003] As described in the *Tank 12H Inventory Determination*, the residual material volume associated with the annulus material, the waste tank wall/column surfaces, and equipment hold-up was determined to be less than 3% of the floor material volume. [SRR-CWDA-2015-00075] The annulus material, waste tank wall/column surfaces, and equipment hold-up volumes were considered represented within the uncertainty of the floor residuals and cooling coil scale volumes. Therefore, the annulus material, waste tank wall/column surfaces, and equipment hold-up materials were not individually sampled for characterization and inventory determination.

Consistent with the presentation: *Proposal to Cease Waste Removal Activities in Tank 12 and Enter Sampling and Analysis Phase*, the Tank 12H CM used a volume estimate of 1,000 gallons for residuals in the primary tank. [SRR-CWDA-2013-00125]

4.1 Final Residual Material Volume Determinations

Note: This section supersedes Tank 12H CM Section 4.1

The final Tank 12H primary tank volume determination and uncertainty estimate were developed using additional photographs and video coverage from the on-board robotic crawler optical system during sampling and with cameras lowered into the tank to record the sampling. The personnel performing the residual material mapping in the primary tank were trained as described in the *Liquid Waste Tank Residuals Sampling – Quality Assurance Program Plan* (LWTRS-QAPP). [SRR-CWDA-2011-00117] The primary tank residual material mapping used the processes described in *Tank Mapping Methodology*. [SRR-LWE-2010-00240] The final primary tank floor material volumes were determined using the methodology described in the *Tank 12 Final Volume Determination and Uncertainty Estimate*. [U-ESR-H-00125] This report also included an estimate for the free-liquid covering the floor solids present at the time of sampling. The scale volume on the cooling coils was determined separately using the methodology described in the *Tank 12 Internal Component Solid Coating Volume Estimation*. [M-CLC-H-03256]

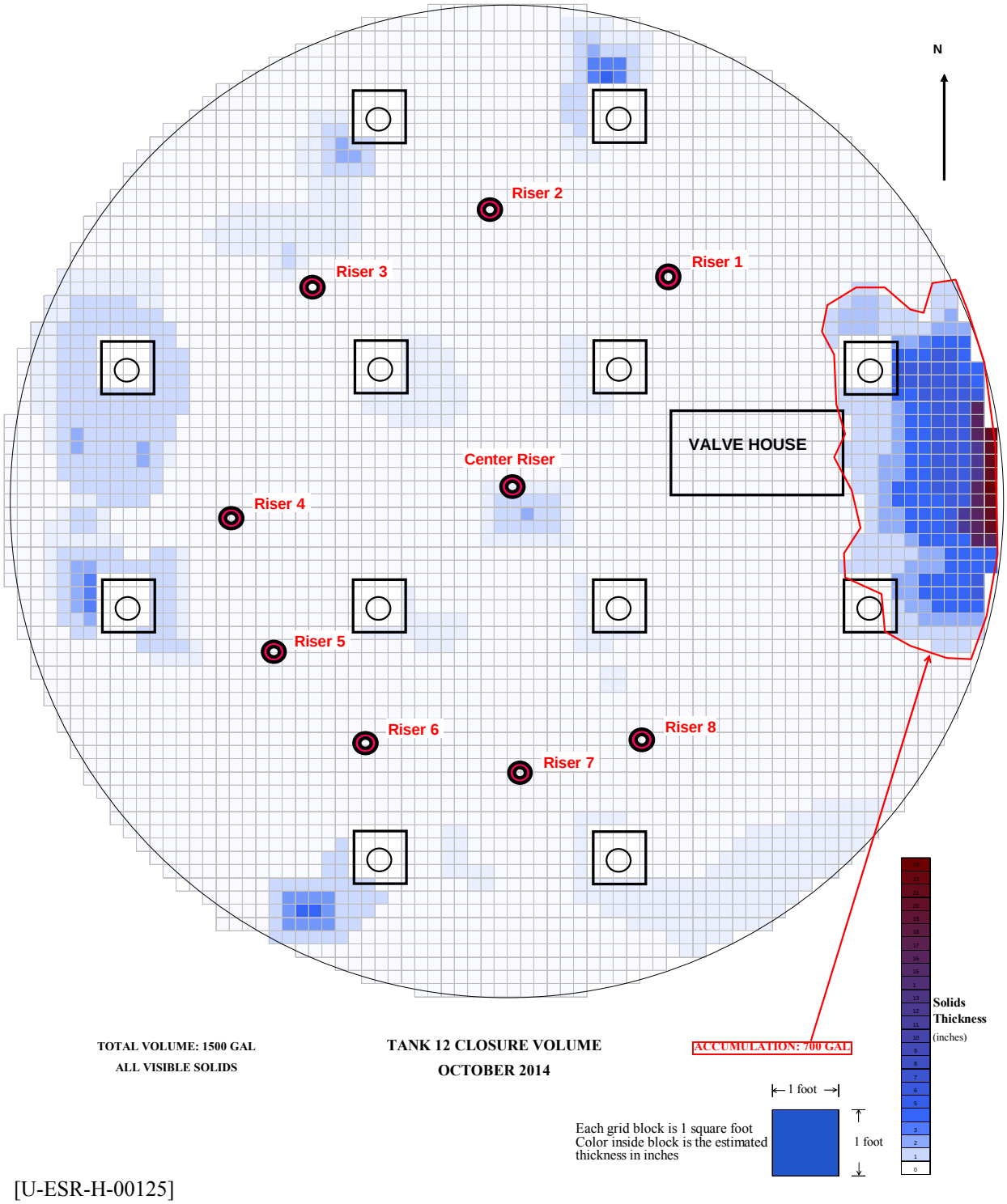
The final residual material volumes used for the inventory determination are presented in Table 4.1-1. The final Tank 12H residual floor solids map is presented in Figure 4.1-1.

Table 4.1-1: Tank 12H Residual Material Volumes

Residual Material	CM Preliminary Volume Estimate (gallons)	CMA Final Volume (gallons)	Notes	Reference
Cooling Coil Scale	400[a]	400	At an elevation approximately 140 inches above the tank floor, a scale material coats the cooling coils and other internal tank surfaces. The scale is heaviest on the coils, possibly as a result of a larger temperature difference with the source material than the wall	M-CLC-H-03256
Residual Floor Solids	1,000	--	The volume estimate of 1,000 gallons used in the CM included 220 gallons in an accumulation beneath the valve house and 780 gallons spread across the primary tank floor in a 0.25 inch thick layer	U-ESR-H-00109
	--	1,500	The final total volume represents the estimated 700 gallons for a mound behind the valve house piping and 800 gallons for the solid material covering the remainder of the tank floor.	U-ESR-H-00125
Free-Liquid	--	3,500	This is the liquid volume determined to be covering the floor solids at the time of sampling	U-ESR-H-00125

[a] Only one volume estimate was calculated for the cooling coil scale

Figure 4.1-1: Tank 12H Primary Tank Residual Solids Map



[U-ESR-H-00125]

4.2 Residual Materials Sampling and Characterization

The sampling and analysis of the Tank 12H residual materials became complicated by the separate analysis of the residual floor solids, cooling coil scale material, and free-liquid. Specific analyte lists were developed for the cooling coil scale and free-liquid, and the number of radionuclides and chemicals reported differ from those reported for the floor residual composite samples. As a result, separate inventories were determined for each of these residual material segments. This complicates the discussion and reporting of the Tank 12H residuals characterization

Figure 4.2-1 shows the sampling and analysis flow path for each of the residual material segments and the associated section in this CMA where the information is presented. The initial sampling plan is described below. Departures from the plan are described in the applicable sections.

Initial Sampling Plan

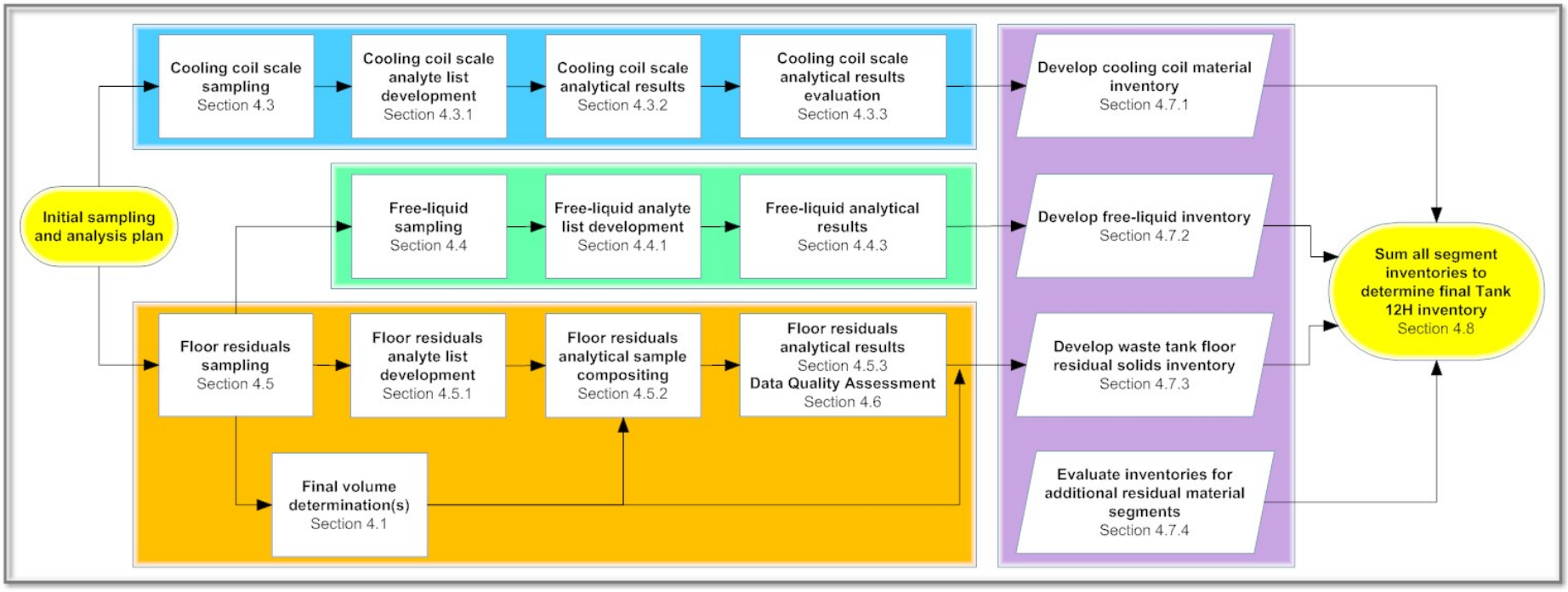
Approximately 800 of the estimated 1,000 gallons of Tank 12H residual floor solids were projected to be spread across the tank floor in a mostly uniform layer approximately 0.25 inches thick. It was also estimated that 220 of the 1,000 gallons of residual solids were in an accumulation (mound) behind the cooling coil piping located beneath the valve house (Table 4.1-1). [U-ESR-H-00109] Based on the mapping of the floor solids movement during the waste removal campaigns, the residuals on the tank floor were assumed to be relatively well-mixed and homogenous. [SRR-CWDA-2014-00056] That assumption was not applicable to the mound behind the cooling coil piping located beneath the valve house.

A statistical evaluation for the optimum number of samples required to best represent the heterogeneity assumed for the mound and possible heterogeneity in the cooling coil material was performed by Savannah River National Laboratory (SRNL). Using the assumptions of two layers in the mound, and a ratio of the sampling standard deviation between a mound layer and the sampling standard deviation for the floor material of approximately six, the statistical evaluation suggested that the sampling uncertainty would be minimized if a total of six samples, arranged in two layers with three samples each, were collected from the mound. The evaluation also assumed three coil scale samples from three different elevations would be collected and used for the analytical sample compositing. [SRNL-STI-2014-00263]

Using the statistical evaluation results, the preliminary residuals volume estimate, and the methodology of the *Liquid Waste Tank Residual Sampling and Analysis Program Plan* (LWTRSAPP), the initial sampling strategy and sample locations were developed in the *Tank 12H Sample Location Determination Report* (SLDR). [SRR-CWDA-2011-00050, SRR-CWDA-2014-00036] Six samples of the solids on the tank floor, six samples from the mound behind the valve house piping, and three samples of the cooling coil scale material were planned for collection and analytical sample compositing as presented in the *Tank 12 Sampling and Analysis Plan* (TSAP). [SRR-LWE-2014-00074] If necessary, a liquid sample would be collected and characterized separately.

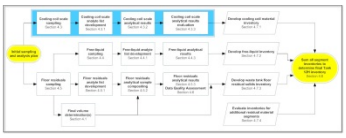
The sampling approach required modification to address situational developments and new information. The final Tank 12H sampling details are discussed and presented in the revised TSAP and summarized in the appropriate sections below. [SRR-LWE-2014-00074]

Figure 4.2-1: Tank 12H Residual Material Characterization Flow Path and Associated CMA Sections



4.3 Cooling Coil Scale Sampling and Characterization

Note: This discussion follows the highlighted sequence in the upper row shown on Figure 4.2-1.

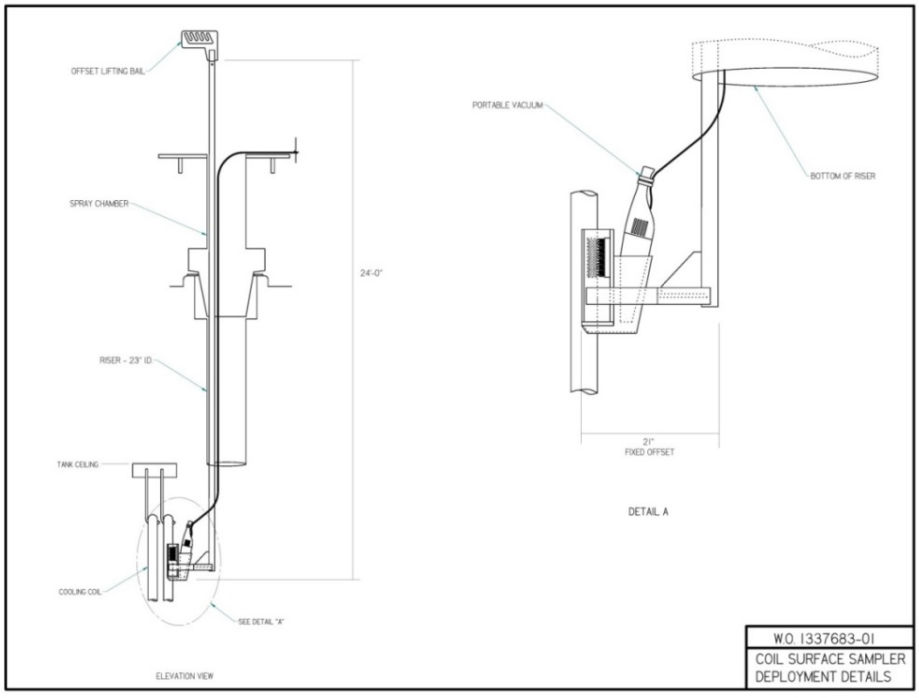


The material coating the cooling coils was collected first, using a specially designed scraping tool with a vacuum collection system (Figure 4.3-1, 4.3-2). Because the material was assumed to be comparable at similar elevations across the tank, and to ensure sufficient material was collected, each sample was collected by scraping the same interval on two adjacent coils using the same tool. The coils were accessed through Riser 8 and sampling started with the T12-R8-C-Low sample at a planned height of approximately 148- to 172-inches above the floor. Similarly, two coils were scraped to collect the T12-R8-C-Mid (188- to 212-inches above the floor) and T12-R8-C-High (223- to 247-inches above the floor) samples.

Because sample collection required manipulating the sampling tool on the end of a 50-foot long pole using a 15-ton crane, it was difficult to control the exact intervals scraped. Measurements checked after the sampling discovered there was an overlap in the upper two intervals sampled. (Table 4.3-1, Figure 4.3-3).

As an early investigation step for the residuals characterization, a limited set of analyses were performed on the coil scale material as discussed in Section 4.3-1. The analytical results are presented and discussed in Section 4.3-2. The inventory determined for the cooling coil scale material is discussed in Section 4.7.1.

Figure 4.3-1: Tank 12H Cooling Coil Sampling Tool



(Not to Scale)

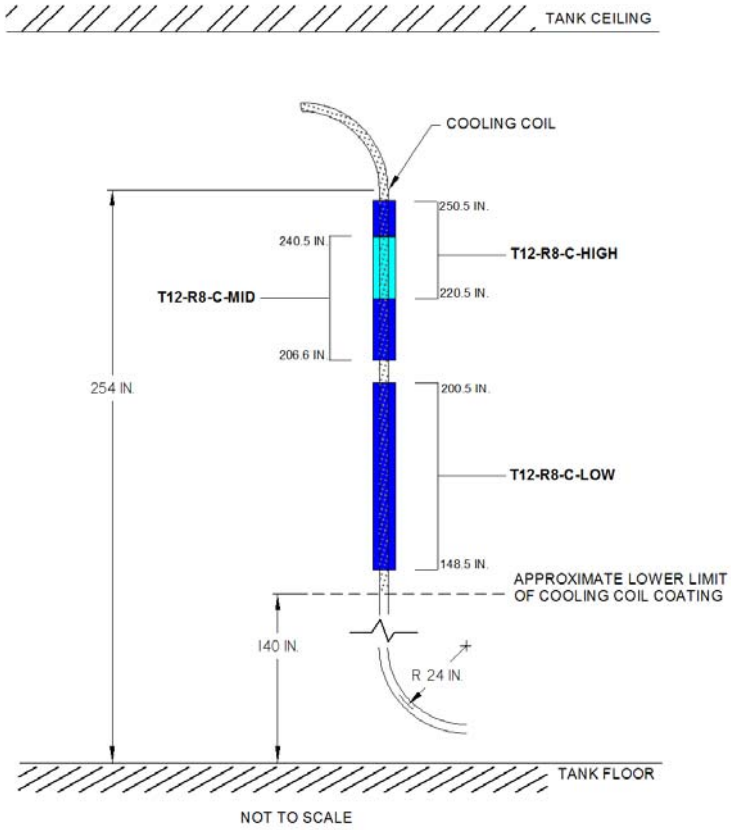
Figure 4.3-2: Tank 12 Cooling Coil Sample Collection Tool

Table 4.3-1: Tank 12H Cooling Coil Sampling Details

Cooling Coil Sample[a]	Planned Sample Interval[b]	Actual Interval Sampled[b]	Sample Weight (g)	Bulk Density[c] (g/ml)	Weight % Solids[d]
T12-R8-C-High	235±12	220.5-250.5	26	3.18±0.18	98.0
T12-R8-C-Mid	200±12	206.6-240.5	47	3.01±0.14	97.8
T12-R8-C-Low	160±12	148.5-200.5	21	3.05±0.02	98.1

[a] Each sample was collected by scraping the same interval on two adjacent coils
[b] Measured in inches above the tank floor
[c] Bulk density of the raw, crystalline material
[d] Measurement made after the material was ground, sieved, and homogenized

Figure 4.3-3: Tank 12H Cooling Coil Sample Intervals Collected



4.3.1 Cooling Coil Scale Analyte List Development

As an early investigation step for the residuals characterization, a limited set of analyses were performed on the coil scale material. When visually examined at the laboratory, all three samples appeared to be the same uniform dull gray, crystalline material. X-ray diffraction analysis of the T12-R8-C-Mid sample showed the material was predominantly montroydite (HgO), with minor gibbsite [$Al(OH)_3$], and preliminary physical measurements showed all the samples had a density of approximately 3.0 grams/ml and were approximately 98 weight percent (wt %) solids (Table 4.3-1). This indicated the material was relatively homogenous. As an early investigation step for the residuals characterization, a limited set of analyses were performed on the coil scale material. Sample T12-R8-C-Mid was selected for the analyses because it contained the most mass and was assumed to be representative of all the coil coating material. The analyte list focused on the major radionuclides that are primarily responsible for contributing to dose and indicative of either a supernate or sludge component, mercury, and metals. The requested analyses were for:

- Routine elemental constituents by inductively coupled plasma-atomic emission spectroscopy (ICP-ES)
- Mercury by cold-vapor atomic absorption (CVAA)
- Co-60, Cs-134, Cs-137, Eu-154, and Am-241 by gamma spectroscopy and cesium-removed gamma spectroscopy
- Tc-99 and Total Alpha by liquid scintillation counting (LSC)

- I-129 by chemical separation and low energy photon, thin windowed, high-purity germanium spectroscopy
- Pu-238 and Pu-239/240 by chemical separation and alpha spectroscopy
- Non-volatile Beta by the sum of cesium-removed non-volatile beta from LSC and Cs-137 from gamma spectroscopy

4.3.2 Cooling Coil Scale Analytical Results

The sample was analyzed once (no replicates). The chemical analytical results are presented in Table 4.3-2. The radionuclide analytical results are presented in Table 4.3-3.

The radionuclide analytical results were reported for the different preparation and analysis methods for completeness and to show the variability in the techniques. The highest value reported for the analyte as a detection, or the lowest minimum detectable concentration (MDC) reported for an analyte with all non-detections, were used for the inventory determination. Further details are presented in the *Tank 12H Inventory Determination*. [SRR-CWDA-2015-00075]

Table 4.3-2: Chemical Analysis Results for Tank 12H Cooling Coil Scale Sample T12-R8-C-Mid

Analyte[a]	Weight Percent (wt %)	Analyte[a]	Weight Percent (wt %)
Silver (Ag)	<1.00E-02	Manganese (Mn)	2.71E-02
Aluminum (Al)	2.33E-01	Molybdenum (Mo)	<1.40E-02
Boron (B)	<1.69E-02	Sodium (Na)	≤1.26E-01[b]
Barium (Ba)	1.96E-03	Nickel (Ni)	6.35E-03
Beryllium (Be)	<1.09E-04	Phosphorous (P)	<3.68E-02
Calcium (Ca)	≤7.03E-03[b]	Lead (Pb)	<1.01E-01
Cadmium (Cd)	<9.88E-04	Sulfur (S)	<9.34E-01
Cerium (Ce)	<8.72E-03	Antimony (Sb)	<3.20E-02
Cobalt (Co)	<1.36E-03	Silicon (Si)	<1.32E-02
Chromium (Cr)	2.68E-03	Tin (Sn)	<7.24E-02
Copper (Cu)	<2.75E-03	Strontium (Sr)	<1.00E-03
Iron (Fe)	8.07E-02	Thorium (Th)	<9.03E-03
Gadolinium (Gd)	<3.46E-03	Titanium (Ti)	<7.24E-04
Mercury (Hg)[c]	9.82E+01	Uranium (U)	<5.44E-02
Potassium (K)	<3.04E-02	Vanadium (V)	<5.37E-04
Lanthanum (La)	<1.53E-03	Zinc (Zn)	1.47E-03
Lithium (Li)	<9.87E-03	Zirconium (Zr)	2.45E-03
Magnesium (Mg)	≤1.97E-03[b]		

[SRNL-STI-2015-00241]

[a] ICP-ES

[b] This result is considered an upper limit since the blank concentration was greater than 10% of the sample concentration

[c] CVAA

Table 4.3-3: Radionuclide Analysis Results for Tank 12H Cooling Coil Scale Sample T12-R8-C-Mid

Analyte	Result (µCi/g)
Cs-134	<5.59E-03[a]
Cs-137	1.25E+00[a]
	1.34E+00[b]
Eu-154	1.28E-01[a]
	1.85E-01[b]
	1.95E-01[c]
Am-241	3.50E-01[a]
	5.23E-01[b]
	5.77E-01[c]
Co-60	1.88E-03[c]
Tc-99	9.64E-03[d]
I-129	1.29E-03[e]
Pu-238	8.38E+00[f]
Pu-239/240	1.84E-01[f]
Total Alpha	<6.35E+00[g]
Non-volatile Beta	1.83E+02[h]

[SRNL-STI-2015-00241]

[a] Peroxide fusion digestion and gamma spectroscopy analysis
[b] Aqua regia digestion and gamma spectroscopy analysis
[c] Cesium-removed gamma spectroscopy analysis
[d] Chemical separation and LSC
[e] Chemical separation and low energy photon, thin windowed, high-purity germanium spectroscopy
[f] Chemical separation and alpha spectroscopy
[g] LSC
[h] Sum of cesium-removed non-volatile beta from LSC and Cs-137 from gamma spectroscopy

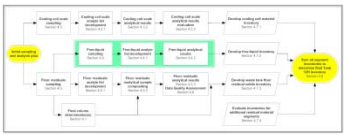
4.3.3 Cooling Coil Scale Analytical Results Evaluation

Because of the high density and large mercury content, the decision was made not to include the material for the analytical sample compositing because its use would preferentially bias the compositing scheme and the resultant inventory determination. Other considerations were that the use of the coil scale material could create analytical separation problems, increase detection limits, and possibly mask any elements present in low concentrations. The decision was made to use the analytical results to develop a separate inventory for the cooling coil scale material as discussed in Section 4.7.1.

During a November 20, 2014 briefing, SCDHEC and the United States Environmental Protection Agency (EPA) were informed of this proposed change and the differences between the planned and actual Tank 12H sampling. [SRR-CWDA-2014-00113]

4.4 Free-Liquid Sampling and Characterization

Note: This discussion follows the highlighted sequence in the middle row shown on Figure 4.2-1.



When Tank 12H was sampled, the floor residual solids were covered by 1- to 2-inches of liquid. To determine the possible need for additional liquid characterization, the liquid in the floor samples was decanted, filtered, and combined. Approximately 170 ml of liquid were collected for analysis. The sample was considered to be representative of the overall liquid in the tank because the residuals and liquid were well-mixed during the waste removal campaigns.

The free-liquid analysis and results are presented and discussed in Section 4.4.2.

Because the mound samples were collected from material above the liquid level, they did not contain appreciable liquid.

4.4.1 Free-Liquid Analyte List Development

The analyte list was focused on the major radionuclides that are primarily responsible for contributing to dose, mercury, and metals. The requested analyses were for:

- Anions by ion chromatography (IC)
- Routine elemental constituents by ICP-ES
- Mercury by CVAA
- Co-60, Cs-137, Eu-154, and Am-241 by gamma spectroscopy and cesium-removed gamma spectroscopy
- Tc-99, Total Alpha, and Non-volatile Beta by LSC
- I-129 by chemical separation and low energy photon, thin windowed, high-purity germanium spectroscopy
- Pu-238 and Pu-239/240 by chemical separation and alpha spectroscopy

4.4.2 Free-Liquid Analyses

The sample was analyzed once (no replicates). The chemical analysis results are presented in Tables 4.4-1 and 4.4-2. The radionuclide analysis results are presented in Table 4.4-3. The laboratory reported 35 elemental analytes for the ICP-ES analyses which includes extra analytes such as calcium, gadolinium, lithium, potassium, magnesium, thorium, zirconium, etc., that are not typically requested or reported for residual material analyses (Table 4.4-1). Unlike the floor residuals composite samples, the liquid sample was not analyzed for arsenic and elemental iodine.

Table 4.4-1: Chemical Analysis Results for Tank 12H Free-Liquid

Analyte[a]	Result (mg/l)	Analyte[a]	Result (mg/l)
Silver (Ag)	<3.90E-02	Manganese (Mn)	9.05E-02
Aluminum (Al)	1.12E+00	Molybdenum (Mo)	<3.59E-01
Boron (B)	<4.35E-01	Sodium (Na)	1.17E+03
Barium (Ba)	<2.00E-02	Nickel (Ni)	<1.02E-01
Beryllium (Be)	<3.00E-03	Phosphorous (P)	<7.15E-01
Calcium (Ca)	5.01E-01	Lead (Pb)	<2.60E+00
Cadmium (Cd)	<2.50E-02	Sulfur (S)	<2.40E+01
Cerium (Ce)	<2.24E-01	Antimony (Sb)	<8.22E-01
Cobalt (Co)	<3.50E-02	Silicon (Si)	8.72E-02
Chromium (Cr)	1.68E-01	Tin (Sn)	<1.86E+00
Copper (Cu)	<7.10E-02	Strontium (Sr)	1.17E-02
Iron (Fe)	1.04E+00	Thorium (Th)	<1.00E+00
Gadolinium (Gd)	<8.90E-02	Titanium (Ti)	<1.90E-02
Mercury (Hg)[b]	2.21E+01	Uranium (U)	3.78E+01
Potassium (K)	1.59E+01	Vanadium (V)	<1.40E-02
Lanthanum (La)	<3.90E-02	Zinc (Zn)	<2.10E-02
Lithium (Li)	<2.54E-01	Zirconium (Zr)	<1.20E-02
Magnesium (Mg)	1.01E-02		

[SRNL-STI-2015-00241]

[a] ICP-ES

[b] CVAA

Table 4.4-2: Anion Analysis Results for Tank 12H Free-Liquid

Analyte	Result (µg/ml)
Fluoride (F)	<1.0E+01
Formate (CHO_2)	<1.0E+01
Chloride (Cl)	3.0E+01
Nitrite (NO_2)	2.0E+01
Bromide (Br)	<1.0E+01
Nitrite (NO_3)	1.13E+02
Phosphate (PO_4)	<1.0E+01
Sulfate (SO_4)	5.7E+01
Oxalate (C_2O_4)	<1.0E+01

[SRNL-STI-2015-00241]

Table 4.4-3: Radionuclide Analysis Results for Tank 12H Free-Liquid

Analyte	Result (µCi/L)
Cs-137	2.17E+02[a]
Eu-154	4.55E-02[b]
	<6.71E+00[a]
Am-241	<7.97E-02[b]
	<1.30E+01[a]
Co-60	<4.08E-03[b]
Tc-99	2.25E-02[c]
I-129	8.83E-03[d]
Pu-238	8.33E-01[e]
Pu-239/240	6.49E-02[e]
Total Alpha	<3.17E+0[f]
Non-volatile Beta	9.28E+02[f]

[SRNL-STI-2015-00241]

[a] Routine gamma spectroscopy analysis
[b] Cesium-removed gamma spectroscopy analysis
[c] Chemical separation and LSC
[d] Chemical separation and low energy photon, thin windowed, high-purity germanium spectroscopy
[e] Chemical separation and alpha spectroscopy
[f] LSC

4.4.3 Free-Liquid Analytical Results

As mentioned earlier, there were an estimated 3,500 gallons of free-liquid present above the floor solids at the time of sampling. Because the ventilation system was still being used to evaporate the liquid, any constituents present in the free-liquid would eventually precipitate and become part of the residual solids on the tank floor. The analytical results were used to develop a separate inventory for the free-liquid as discussed in Section 4.7.2.

The radionuclide analytical results were reported for the different analysis methods for completeness and to show the variability in the techniques. For detected constituents, the mean concentrations were used for the liquid inventory determination. For constituents that were not detected, the lowest MDC was used for the inventory determination. Further details are presented in the *Tank 12H Inventory Determination*. [SRR-CWDA-2015-00075]

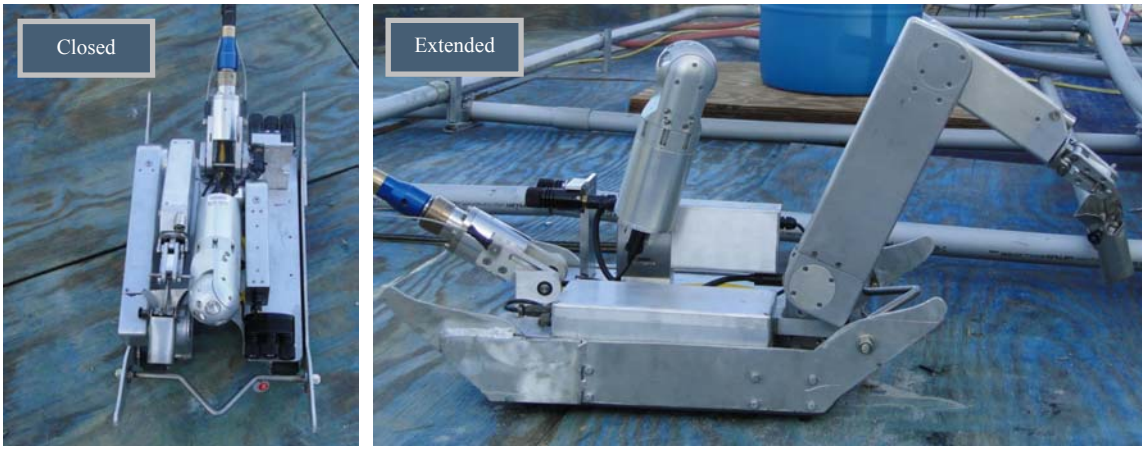
4.5 Floor Residuals Sampling and Characterization

Note: This discussion follows the highlighted sequence in the bottom row shown on Figure 4.2-1.

Details for the final residual material sampling are presented in the revised Tank 12H TSAP and summarized below. [SRR-LWE-2014-00074]

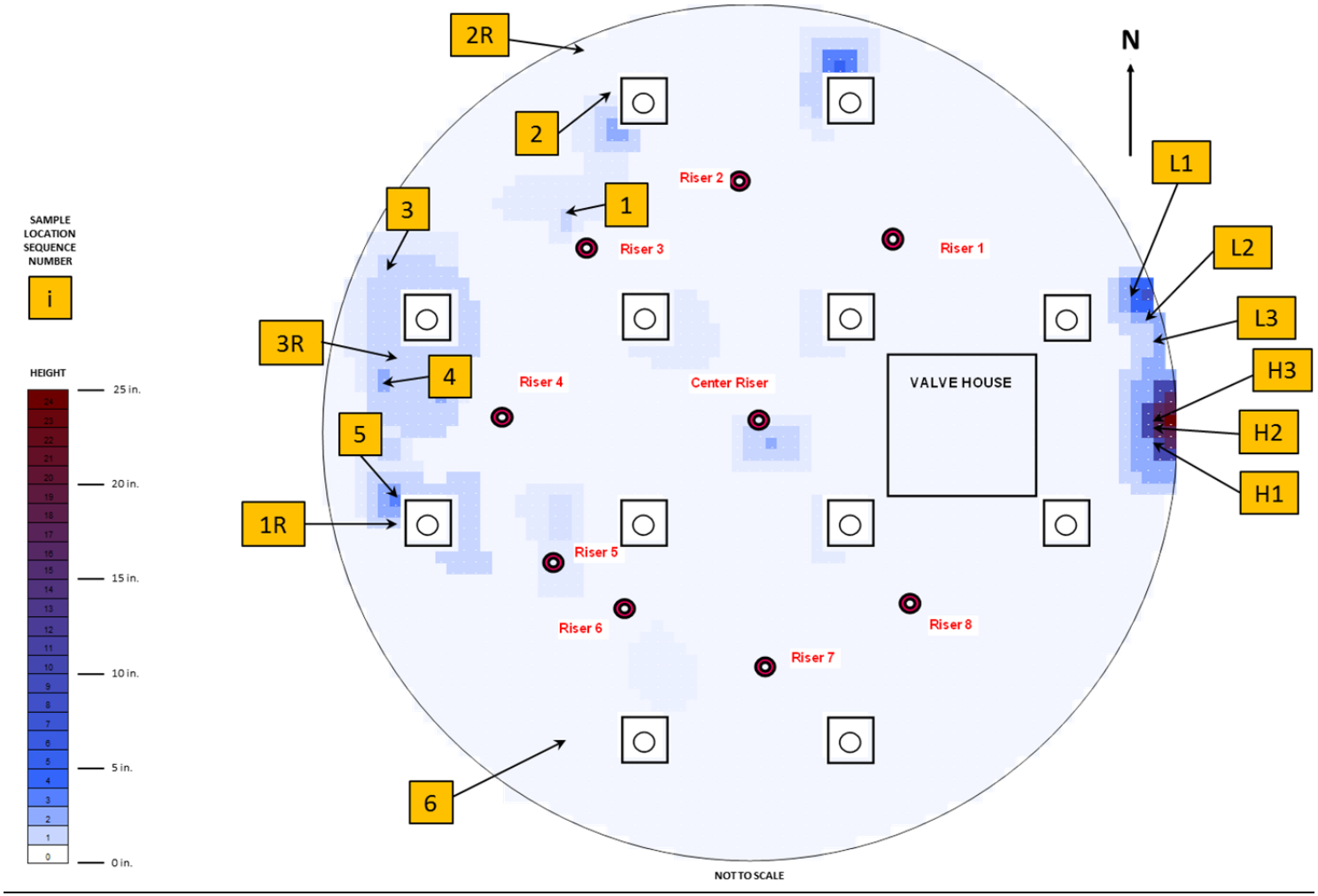
The floor and mound residuals sampling was performed using robotic crawlers (Figure 4.5-1). Four of the first six floor residuals samples collected and opened at the laboratory (T12-F-1, T12-F-2, T12-F-3, and T12-F-6) did not contain any appreciable material and resampling was required. The poor sample recoveries are likely the result of either no material being present at those locations or material loss during sampler retrieval. Because sampling was conducted with a 1- to 2-inch deep liquid layer present over the floor solids, it was difficult to initially judge how much solid material was actually being recovered. Because the floor material was assumed to be well-mixed, the three original sample locations were moved to areas thought to have more residual material, and resamples T12-F-1R, T12-F-2R, and T12-F-3R were collected. A resample was not collected at T12-F-6 because of the apparent lack of material and the high possibility of crawler entrapment associated with returning to that location. As a result, only five of the six planned floor samples for compositing were collected. The final tank floor sampling locations are shown on Figure 4.5-2.

Figure 4.5-1: Modified Sample Crawler With Arm Closed and Fully Extended (Mockup)



As the crawler was driven along the northern perimeter of the tank and reached the mound location, three large “boulders” of material were encountered (Figure 4.5-3). The estimated 12-inch height and angular appearance of the boulders was considered an indication that they had not been significantly transported or disturbed. After considering the high possibility of crawler entrapment or inability to reach the mound location, one sample from each of the boulders was collected as a contingency measure. The crawler arm was used to dig into each boulder and darker, interior material was collected. Because the boulders were estimated to be a maximum 12 inches in height, and the preliminary mound height had been estimated at 24 inches high, these boulder samples were interpreted as representing the lower portion of the mound. [SRR-LWE-2014-00074]

Figure 4.5-2: Final Tank 12H Floor Sampling Locations



The crawler was able to reach the mound behind the valve house cooling coil piping and a fissure extending into the mound flank was observed. The fissure was sufficiently wide to allow the crawler to partially enter, and the arm was able to reach a height approximately 16 inches above the floor to collect the three upper mound samples (Figure 4.5-3). A scoop was used with the crawler arm to dig into the mound mass and expose darker, interior material for sampling. In this area, a small portion of the upper mound bordering the tank wall was estimated to have a height exceeding 24 inches above the tank floor.

Both the boulder (lower mound) and upper mound samples were collected after digging into the interior of the material masses. The interior boulder material sampled was significantly darker that the exterior material and was assumed not to have been as impacted by waste removal efforts. Similarly, the upper mound samples were collected from the mound mass interior where the material color was also much darker and the material appeared to be harder as indicated by the effort required by the crawler to dig into the mound.

All samples collected were shipped to SRNL under chain-of-custody per requirements of the LWTRSAPP. Additional sampling details are presented in the updated Tank 12H TSAP. [SRR-LWE-2014-00074]

Figure 4.5-3: Tank 12H "Boulder" (Lower Mound) and Upper Mound Sampling Locations

4.5.1 Floor Residuals Analyte List Development

The analyte list development for the floor residual sample analyses started with the 54 radionuclides and 50 chemicals identified as "of concern" in the closure inventory document for the HTF Performance Assessment (PA). [SRR-CWDA-2010-00023] The final chemical and radionuclide analyte lists were developed using process knowledge and the screening process described in the *Recommended Radionuclide and Chemical Analyte List for Tank 12*. A total of 27 chemicals and 35 radionuclides were recommended for the composite sample analyses. [SRR-CWDA-2014-00052]

The chemical analyte list is presented in Table 4.5-1. The radionuclide analyte list is presented in Table 4.5-2.

The analyte lists are different for the cooling coil scale and free-liquid analyses. As described earlier, the scale and liquid analyses were focused on rapid determination of only

the dose-contributing radionuclides and general chemical analytes to base decisions for performing more in-depth sampling and analyses.

Table 4.5-1: Chemical Analyte List for Tank 12H Composite Samples

Chemicals	
Silver (Ag)	Molybdenum (Mo)
Aluminum (Al)	Nickel (Ni)
Arsenic (As)	Nitrite (NO_2)
Boron (B)	Nitrate (NO_3)
Barium (Ba)	Lead (Pb)
Cadmium (Cd)	Phosphate (PO_4)
Chloride (Cl)	Antimony (Sb)
Cobalt (Co)	Selenium (Se)
Chromium (Cr)	Sulfate (SO_4)
Copper (Cu)	Strontium (Sr)
Fluoride (F)	Thorium (Th)
Iron (Fe)	Uranium (U)
Mercury (Hg)	Zinc (Zn)
Iodine (I)	Zirconium (Zr)
Manganese (Mn)	

[SRR-CWDA-2014-00086]

Table 4.5-2: Radionuclide Analyte List for Tank 12H Composite Samples

Radionuclides			
Am-241	Cs-137	Pu-240	Th-232
Am-242m	I-129	Pu-241	U-232
Am-243	Nb-94	Ra-226	U-233
Ba-137m	Ni-59	Ra-228	U-234
C-14	Ni-63	Sn-126	U-235
Cm-243	Np-237	Sr-90	U-238
Cm-244	Pa-231	Tc-99	Y-90
Cm-245	Pu-238	Th-229	Zr-93
Cs-135	Pu-239	Th-230	

[SRR-CWDA-2014-00086]

4.5.2 Floor Residuals Analytical Sample Compositing

The analytical sample compositing plan was revised to account for the retrieval of only 5 out of the 6 planned floor samples and the decision not to use the cooling coil samples for the compositing.

Three possible compositing options using the 11 floor and mound samples were evaluated by an SRNL statistician. The options evaluation considered the sampling variability and the impact on the variance of the sample means for the composite sample creation. [SRNL-STI-2014-00551] The decision was made to use only four instead of the five samples per analytical composite as specified in the LWTRSAPP compositing methodology, and to split one sample (T12-F-4) for use in two of the composites. The final compositing scheme is shown in Table 4.5-3.

Table 4.5-3: Tank 12H Floor Residuals Analytical Sample Compositing

Material Segment	Composite No. 1	Composite No. 2	Composite No. 3
Mound	T12-M-L-1	T12-M-L-2	T12-M-L-3
Mound	T12-M-H-1	T12-M-H-2	T12-M-H-3
Floor	T12-F-4	T12-F-2R	T12-F-1R
Floor	T12-F-5	T12-F-3R	T12-F-4

The final volume determination and the sample densities were used to determine the mass of each sample for the composite sample creation. The final compositing calculation is presented in the *Tank 12H Sample Compositing Determination.* [SRR-CWDA-2014-00103] Because only 20 grams of material was collected at location T12-F2-R, the composite sample weight was reduced to 60 grams instead of the typical 70 grams desired. The smaller composite sample size did not impact the analyte list or the requested target detection limits (TDLs).

4.5.3 Floor Residuals Analytical Results

SRNL analyzed the floor residuals composite samples in triplicate for the requested constituents. Therefore, nine results per analyte were available for further statistical evaluation, except for Th-229, which only had eight due to a missing result in Composite Sample 3. Details of the analyses, analytical results, and statistical analysis of the results, are provided in the *Tank 12H Residuals Sample Analysis Report*. [SRNL-STI-2015-00241] The analytical results are presented in Table 4.5-4 for analytes having detectable concentrations, and in Table 4.5-5 for analytes having all results below the MDC.

A statistical study on the applicable analytical results was performed. The results were tested for outliers and goodness-of-fit to identify the appropriate data distribution and estimation method used to provide the mean, standard deviation, and Upper 95% Confidence Limit (UCL95) for each analyte. No statistics could be performed on analytes having all results below the MDC. Additional details are presented in the *Tank 12H Residuals Sample Analysis Report.* [SRNL-STI-2015-00241]

In conjunction with the final volume determination, the analytical results were used to develop the inventory for the floor residuals as discussed in Section 4.7.

Table 4.5-4: Tank 12 Floor Residuals Composite Sample Results for Analytes Having Measured Concentrations

Analyte	Mean (µCi/g)	UCL95 (µCi/g)	Standard Deviation (µCi/g)	Analyte	Mean (wt %)	UCL95 (wt %)	Standard Deviation (wt %)
Am-241	1.24E+01	2.13E+01	5.25E+00	Silver (Ag)	6.06E-02	1.06E-01	2.71E-02
Am-242m	3.08E-03	5.17E-03	1.24E-03	Aluminum (Al)	7.08E+00	1.06E+01	2.14E+00
Am-243	1.84E-02	2.60E-02	4.78E-03	Arsenic (As)	2.16E-04	2.62E-04	2.96E-05
Ba-137m[a]	8.25E+00	1.24E+01	2.60E+00	Boron (B)	9.67E-02	1.41E-01	2.65E-02
Cs-137	8.72E+00	1.31E+01	2.74E+00	Barium (Ba)	6.88E-02	7.09E-02	3.30E-03
I-129	4.55E-03	5.04E-03	7.96E-04	Cadmium (Cd)	2.50E-03	3.49E-03	5.92E-04
Ni-59	1.90E-01	3.13E-01	7.36E-02	Chloride (Cl)	1.62E-02	1.69E-02	1.11E-03
Ni-63	1.97E+01	3.04E+01	6.37E+00	Cobalt (Co)	4.36E-03	6.72E-03	1.41E-03
Np-237	1.25E-02	2.52E-02	7.54E-03	Chromium (Cr)	5.00E-02	7.57E-02	1.53E-02
Pa-231	1.29E-03	2.44E-03	6.78E-04	Copper (Cu)	1.54E-01	1.98E-01	2.69E-02
Pu-238	8.94E+01	1.55E+02	3.95E+01	Iron (Fe)	3.01E+01	4.20E+01	7.12E+00
Pu-239	3.80E+00	6.68E+00	1.73E+00	Mercury (Hg)	1.56E+01	2.21E+01	3.88E+00
Pu-240	1.37E+00	2.47E+00	6.60E-01	Iodine (I)[c]	2.72E-03	3.03E-03	4.95E-04
Pu-241	2.06E+01	3.73E+01	1.02E+01	Manganese (Mn)	1.36E+00	1.71E+00	2.09E-01
Ra-228	4.70E-03	7.82E-03	1.91E-03	Molybdenum (Mo)	1.37E-03	1.51E-03	1.71E-04
Sn-126	1.73E-02	2.22E-02	3.04E-03	Nickle (Ni)	7.72E-01	1.18E+00	2.43E-01
Sr-90	1.53E+04	1.94E+04	2.61E+03	Nitrite (NO_2)	5.78E-03	1.02E-02	2.67E-03
Tc-99	4.12E-03	4.48E-03	5.77E-04	Nitrate (NO_3)	1.46E-02	1.57E-02	1.78E-03
Th-232	5.46E-03	1.06E-02	3.05E-03	Lead (Pb)	3.44E-02	3.87E-02	2.81E-03
U-232	3.38E-03	4.09E-03	1.14E-03	Sulfate (SO_4)	7.88E-02	1.22E-01	2.62E-02
U-234	5.70E-03	8.73E-03	1.81E-03	Strontium (Sr)	4.45E-02	5.44E-02	6.01E-03
U-235	2.90E-05	5.45E-05	1.52E-05	Thorium (Th)	4.96E+00	9.66E+00	2.79E+00
U-238	4.42E-04	9.38E-04	2.95E-04	Uranium (U)	8.78E-02	1.82E-01	5.61E-02
Y-90[b]	1.53E+04	1.94E+04	2.61E+03	Zinc (Zn)	3.31E-02	3.72E-02	2.60E-03
Zr-93	4.56E-01	6.34E-01	1.07E-01	Zirconium (Zr)	1.19E-01	1.66E-01	2.84E-02

[SRNL-STI-2015-00241]

[a] Based on equilibrium relationship with Cs-137

[b] Based on equilibrium relationship with Sr-90

[c] Value represents total iodine consisting of I-129 and I-127

Table 4.5-5: Tank 12 Floor Residuals Composite Sample Results for Analytes All Below Minimum Detectable Concentrations

Analyte	Lowest MDC (µCi/g)	Highest MDC (µCi/g)	Analyte	Lowest MDC (wt %)	Highest MDC (wt %)
C-14	<5.05E-04	<8.83E-04	Fluoride (F)	<2.93E-03	<3.06E-03
Cm-243	<1.22E-02	<1.88E-02	Phosphate (PO_4)	<2.93E-03	<3.06E-03
Cm-244	<3.34E-01	<6.98E-01	Antimony (Sb)	<1.92E-04	<2.00E-04
Cs-135	<1.00E-05	<8.06E-05	Selenium (Se)	<2.88E-04	<2.99E-04
Nb-94	<4.36E-04	<1.23E-03			
Ra-226	<4.68E-04	<7.75E-04			
Th-229	<2.04E-04	<4.10E-03			
Th-230	<3.52E-04	<1.62E-03			
U-233	<3.23E-02	<8.53E-02			

[SRNL-STI-2015-00241]

4.6 Data Quality Assessment (DQA)

A DQA was performed to assess the usability of the characterization data for the Tank 12H inventory determination. [SRR-CWDA-2015-00084] The final sampling plan and compositing scheme were shown to be sufficient to representatively characterize the waste tank residual materials.

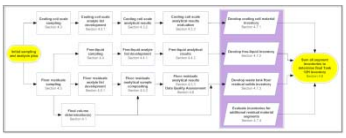
Overall, the Tank 12H composite sample results appeared to be uniform with minor statistical differences. The small statistical variance for the NO_3, Pu-239, and Np-237 analyses in Composite Sample 2 was attributed to the material heterogeneity and not the measurement techniques. An Am-243 outlier was also identified and not used in the subsequent UCL95 calculation. Reviews of the precision, accuracy, representativeness, completeness, and the statistical analysis indicated the data are sufficient to characterize the residual material.

The DQA determined that the analytical data were considered usable for the purpose of characterizing the Tank 12H residual materials and to support the inventory determination.

The cooling coil scale material and free-liquid samples were analyzed only once for the requested analytes and only a limited review of that data could be performed as part of the DQA. The samples were analyzed using SRNL's routine Quality Assurance (QA) protocols instead of the QA protocols specified in the LWTRS-QAPP. The cooling coil and liquid analyses were requested and performed rapidly to guide the decisions on the need for additional sampling and analyses, and the use of the coil material in the composite sample creation and the rigorous documentation specified in the LWTRS-QAPP was not requested. The analysis requirements, such as equipment calibration, use of blanks, etc., and analytical results were reviewed and approved by the Principal Investigator before they were issued. Savannah River Remediation LLC (SRR) personnel also reviewed and accepted the data for subsequent decision making and to develop individual inventories for the cooling coil scale and liquid portions of the Tank 12H residuals.

4.7 Tank 12H Inventory

Note: This discussion describes the highlighted sequence shown in the column on Figure 4.2-1.



Radiological and chemical inventories were developed for each of the residual material segments that will remain in Tank 12H. The sum of the individual segment inventories is the final Tank 12H inventory. The individual radionuclide inventories are calculated for the year 2015 and are not decay corrected to 2032, which is the year that closure of the HTF was assumed in the HTF PA. However, the final Tank 12H radionuclide inventory is decay corrected to 2032. The chemical inventories do not require correction.

The contributing segment inventories determined by actual sampling and analysis are:

- Cooling coil surface (scale) residuals
- Free-liquid in the primary tank at the time of sampling
- Waste tank floor residual solids

The residual material inventories associated with the other primary tank segments such as the interior wall/column surfaces, equipment hold-up, and the volume of dried residual solids in the annulus, were determined by estimation or by engineering evaluation and considered to be insignificant and represented in the volume uncertainty for the residual floor solids. [SRR-CWDA-2015-00075]

The inventory development for each of these segments is summarized below.

The floor residual composite samples are typically analyzed in triplicate, so for three composite samples, a maximum of nine results can be reported. The results are statistically evaluated and the UCL95 of the mean for all nine results is typically used for the constituent inventory concentration calculation. For constituents where all nine results are non-detects, the lowest MDC result is used to determine the inventory. For constituent results having a mixture of detects and non-detects, the constituent results are treated as detects if there are a sufficient number of detectable results. A UCL95 is calculated for these constituents using statistical methods. If there is not a sufficient number of detectable results then the constituent results are treated as non-detects and the lowest MDC result is used to determine the inventory. Additional details on the methodology used to develop the individual segment and final waste tank inventory is presented in the *Tank 12H Inventory Determination*. [SRR-CWDA-2015-00075]

The Ba-137m concentrations reported for the cooling coil scale and free-liquid were used to determine the Cs-137 concentrations that were used in the respective inventory development. For the Sr-90/Y-90 inventories, the non-volatile beta concentration, minus the Cs-137 concentration, was divided equally between Sr-90 and Y-90 for inventory development.

While Cs-134, Eu-154, and Co-60 results were reported for the cooling coils scale and free-liquid analyses, inventories were not developed because these radionuclides have half-lives less than 6 years and have an insignificant contribution to dose.

4.7.1 Cooling Coil and Interior Tank 12H Surface (Scale) Material Inventory

The radionuclide and chemical inventories for the scale coating the cooling coils and interior Tank 12H interior surfaces were developed using the analytical results discussed in Section 4.3.2. As mentioned earlier, the analyses were performed once and only used the mid-level sample. The volume of scale on the coils, interior tank wall, and column surfaces was calculated at 400 gallons. [M-CLC-H-03256] The chemical and radionuclide inventories determined for the scale coating are presented in Tables 4.7-1 and 4.7-2 respectively.

The radionuclide analytical results were reported for the different preparation and analysis methods for completeness and to show the variability in the techniques. The highest value reported for the analyte, either as a detection, or the lowest MDC reported for an analyte with all non-detections, were used for the inventory determination. Further details are presented in the *Tank 12H Inventory Determination*. [SRR-CWDA-2015-00075]

The individual analyte inventories listed in Tables 4.7-1 and 4.7-2 were added to the floor residuals and free-liquid inventories for the final Tank 12H inventory determination.

Table 4.7-1: Chemical Inventory for Scale Coating the Cooling Coils and Interior Tank 12H Surfaces

Analyte	Inventory (kg)	Analyte	Inventory (kg)
Silver (Ag)	4.6E-01	Manganese (Mn)	1.2E+00
Aluminum (Al)	1.1E+01	Molybdenum (Mo)	6.4E-01
Boron (B)	7.7E-01	Nickel (Ni)	2.9E-01
Barium (Ba)	9.0E-02	Lead (Pb)	4.6E+00
Cadmium (Cd)	4.5E-02	Antimony (Sb)	1.5E+00
Cobalt (Co)	6.2E-02	Strontium (Sr)	4.6E-02
Chromium (Cr)	1.2E-01	Thorium (Th)	4.1E-01
Copper (Cu)	1.3E-01	Uranium (U)	2.5E+00
Iron (Fe)	3.7E+00	Zinc (Zn)	6.7E-02
Mercury (Hg)	4.5E+03	Zirconium (Zr)	1.1E-01

[SRR-CWDA-2015-00075]

Table 4.7-2: Radionuclide Inventory for Scale Coating the Cooling Coils and Interior Tank 12H Surfaces

Analyte	Inventory (2015) (Ci)
Am-241	2.6E+00
Ba-137m[a]	5.8E+00
Cs-137	6.1E+00
I-129	5.9E-03
Pu-238	3.8E+01
Pu-239	8.4E-01
Pu-240	8.4E-01
Sr-90	4.1E+02
Tc-99	4.4E-02
Y-90[b]	4.1E+02

[SRR-CWDA-2015-00075]

[a] Based on equilibrium relationship with Cs-137

[b] Based on equilibrium relationship with Sr-90

4.7.2 Free-Liquid Residual Inventory

The radionuclide and chemical inventories for the free-liquid above the floor solids at the time of sampling were developed using the analytical results discussed in Section 4.4.2. As mentioned earlier, the analyses were performed once on the combined liquid fraction decanted from the floor residual samples. The liquid volume was estimated at 3,500 gallons at the time of sampling. [U-ESR-H-00125] The chemical and radionuclide inventories determined for the liquid are presented in Tables 4.7-3 and 4.7-4 respectively.

The radionuclide analytical results were reported for the different analysis methods for completeness and to show the variability in the techniques. For detected constituents, the mean concentrations were used for the liquid inventory determination. For constituents that were not detected, the lowest MDC was used for the inventory determination. Further details are presented in the *Tank 12H Inventory Determination*. [SRR-CWDA-2015-00075]

The individual analyte inventories listed in Tables 4.7-3 and 4.7-4 were added to the floor residuals and free-liquid inventories for the final Tank 12H inventory determination.

Table 4.7-3: Chemical Inventory for the Tank 12H Free-Liquid

Constituent	Inventory (kg)	Constituent	Inventory (kg)
Silver (Ag)	5.2E-04	Molybdenum (Mo)	4.8E-03
Aluminum (Al)	1.5E-02	Nickel (Ni)	1.4E-03
Boron (B)	5.8E-03	Nitrite (NO_2)	2.6E-01
Barium (Ba)	2.6E-04	Nitrate (NO_3)	1.5E+00
Cadmium (Cd)	3.3E-04	Lead (Pb)	3.4E-02
Chloride (Cl)	4.0E-01	Phosphate (PO_4)	1.3E-01
Cobalt (Co)	4.6E-04	Antimony (Sb)	1.1E-02
Chromium (Cr)	2.2E-03	Sulfate (SO_4)	7.6E-01
Copper (Cu)	9.4E-04	Strontium (Sr)	1.5E-04
Fluoride (F)	1.3E-01	Thorium (Th)	1.3E-02
Iron (Fe)	1.4E-02	Uranium (U)	5.0E-01
Mercury (Hg)	2.9E-01	Zinc (Zn)	2.8E-04
Manganese (Mn)	1.2E-03	Zirconium (Zr)	1.6E-04

[SRR-CWDA-2015-00075]

Table 4.7-4: Radionuclide Inventory for the Tank 12H Free-Liquid

Constituent	Inventory (2015) (Ci)
Am-241	1.7E-01
Ba-137m[a]	2.7E+00
Cs-137	2.9E+00
I-129	1.2E-04
Pu-238	1.1E-02
Pu-239	8.6E-04
Pu-240	8.6E-04
Sr-90	6.1E+00
Tc-99	3.0E-04
Y-90[b]	6.1E+00

[SRR-CWDA-2015-00075]

[a] Based on equilibrium relationship with Cs-137

[b] Based on equilibrium relationship with Sr-90

4.7.3 Waste Tank Floor Residual Solids Inventory

The primary tank floor residuals inventory was developed using the 1,500 gallons final volume, the composite sample densities, composite sample solids content, and the chemical and radionuclide analytical results. Three composite samples were analyzed to determine the average concentrations of the floor material. Because the floor samples were collected while the tank had a layer of free-liquid, conservatisms in the material density and solids content

were used to convert the analytical results to inventory values as described in the *Tank 12H Inventory Determination*. [SRR-CWDA-2015-00075]

The radionuclide and chemical inventories were determined for the primary tank floor residuals using the results presented in Section 4.5.3. The chemical and radionuclide inventories are presented in Tables 4.7-5 and 4.7-6 respectively. As mentioned earlier, the radionuclide inventories were calculated for the year 2015 and are not decay corrected to 2032, which is the year that closure of the HTF was assumed in the HTF PA. The final (total) Tank 12H inventory is decay corrected to 2032.

Table 4.7-5: Chemical Inventory for the Tank 12H Waste Tank Floor Residual Solids

Analyte	Inventory (kg)	Analyte	Inventory (kg)
Silver (Ag)	6.7E+00	Molybdenum (Mo)	9.5E-02
Aluminum (Al)	6.6E+02	Nickel (Ni)	7.4E+01
Arsenic (As)	1.6E-02	Nitrite (NO_2)	6.4E-01
Boron (B)	8.8E+00	Nitrate (NO_3)	9.9E-01
Barium (Ba)	4.4E+00	Lead (Pb)	2.4E+00
Cadmium (Cd)	2.2E-01	Phosphate (PO_4)	<1.8E-01
Chloride (Cl)	1.1E+00	Antimony (Sb)	<1.2E-02
Cobalt (Co)	4.2E-01	Selenium (Se)	<1.8E-02
Chromium (Cr)	4.7E+00	Sulfate (SO_4)	7.6E+00
Copper (Cu)	1.2E+01	Strontium (Sr)	3.4E+00
Fluoride (F)	<1.8E-01	Thorium (Th)	6.1E+02
Iron (Fe)	2.6E+03	Uranium (U)	1.1E+01
Mercury (Hg)	1.4E+03	Zinc (Zn)	2.3E+00
Iodine (I)	1.9E-01	Zirconium (Zr)	1.0E+01
Manganese (Mn)	1.1E+02		

[SRR-CWDA-2015-00075]

Table 4.7-6: Radionuclide Inventory for the Tank 12H Waste Tank Floor Residual Solids

Analyte	Inventory (2015) (Ci)	Analyte	Inventory (2015) (Ci)
Am-241	1.3E+02	Pu-240	1.7E+01
Am-242m	3.2E-02	Pu-241	2.3E+02
Am-243	1.6E-01	Ra-226	<2.9E-03
Ba-137m[a]	8.7E+01	Ra-228	4.9E-02
C-14	<3.2E-03	Sn-126	1.4E-01
Cm-243	<7.7E-02	Sr-90	1.2E+05
Cm-244	<2.1E+00	Tc-99	7.2E-02
Cm-245	3.0E-04	Th-229	<1.3E-03
Cs-135	<6.3E-05	Th-230	<2.2E-03
Cs-137	9.1E+01	Th-232	6.6E-02
I-129	3.8E-02	U-232	2.6E-02
Nb-94	<2.7E-03	U-233	<2.0E-01
Ni-59	2.0E+00	U-234	5.5E-02
Ni-63	1.9E+02	U-235	3.4E-04
Np-237	1.6E-01	U-238	5.9E-03
Pa-231	1.5E-02	Y-90[b]	1.2E+05
Pu-238	1.0E+03	Zr-93	4.0E+00
Pu-239	4.3E+01		

[SRR-CWDA-2015-00075]

[a] Based on equilibrium relationship with Cs-137

[b] Based on equilibrium relationship with Sr-90

4.7.4 Equipment Hold-up and Annulus Material Inventories

The inventories associated with any residual materials retained, or "held-up" in the interval void space of equipment that will remain in the waste tank at the time of RFS was evaluated. These inventories were determined by estimation or by engineering evaluation rather than by sampling and analysis. The evaluation is presented below.

The inventories were considered to be insignificant and represented in the volume uncertainty for the residual floor solids. [SRR-CWDA-2015-00075]

Primary Tank Equipment Hold-Up

Various pieces of equipment used during the tank operation and waste removal processes will remain in Tank 12H when it is removed from service. Some of the equipment has the potential to contain, or "hold-up," residual material in the interior void space.

The equipment remaining in the primary tank includes a transfer pump, a dewatering pump, a transfer jet, and two robotic crawlers. [SRR-LWE-2014-00161] The estimated residual waste hold-up volume in the transfer pump and transfer jet is 10 gallons. [SRR-LWE-2014-00161] The crawlers do not have any internal void space for material hold-up.

Because the 10 gallons total hold-up volume is less than 1% of the tank residuals volume, The inventories were considered to be insignificant and represented in the volume uncertainty for the residual floor solids. [SRR-CWDA-2015-00075] No separate inventory was calculated for this material. [SRR-CWDA-2015-00075]

Any inventory associated with the equipment surface is also expected to be minimal since this equipment would have experienced treatment conditions similar to the residual material on the floor.

Waste Tank Annulus Equipment Hold-Up

The Tank 12H annulus contains an annulus transfer jet with an estimated residual waste hold-up volume of 3 gallons. [SRR-LWE-2014-00161] Any inventory associated with this volume were considered to be insignificant and represented in the volume uncertainty for the residual floor solids. [SRR-CWDA-2015-00075]

Waste Tank Annulus

A volume of 25 gallons was assigned to the dried salt waste present in the Tank 12H annulus as a result of leakage through 15 leak sites in the primary liner wall. [C-ESR-G-00003] Because the 25 gallons total volume represents less than 2% of the 1,500 gallons estimated for the floor residuals volume, it is considered represented in the volume uncertainty for the residual floor solids. A separate annulus inventory was not determined.

4.8 Final Tank 12H Residuals Inventory

The methodology used to develop the total Tank 12H inventory sums the inventories for each contributing portion of the waste tank residuals and is described in the Tank 12H Inventory Determination. [SRR-CWDA-2015-00075]

The final Tank 12H chemical inventory is the total of the chemical inventories for the cooling coil scale material (Table 4.7-1), the free-liquid above the floor solids (Table 4.7-3), and the floor residual floor solids (Table 4.7-5). The final Tank 12H chemical inventory is presented in Table 4.8-1.

The final Tank 12H radionuclide inventory is the total of the radionuclide inventories for the cooling coil scale material (Table 4.7-2), the free-liquid above the floor solids (Table 4.7-4), and the floor residual floor solids (Table 4.7-6). Table 4.8-2 shows the final inventory for 2015 and the inventory decay corrected for 2032, which is the year that closure of the HTF was assumed in the HTF PA.

Table 4.8-1: Final Tank 12H Residuals Chemical Inventory

Constituent	Tank 12H Final Inventory (kg)	Constituent	Tank 12H Final Inventory (kg)
Silver (Ag)	7.1E+00	Molybdenum (Mo)	7.4E-01
Aluminum (Al)	6.7E+02	Nickel (Ni)	7.4E+01
Arsenic (As)	1.6E-02	Nitrite (NO_2)	9.1E-01
Boron (B)	9.6E+00	Nitrate (NO_3)	2.5E+00
Barium (Ba)	4.5E+00	Lead (Pb)	7.1E+00
Cadmium (Cd)	2.6E-01	Phosphate (PO_4)	<3.2E-01
Chloride (Cl)	1.5E+00	Antimony (Sb)	<1.5E+00
Cobalt (Co)	4.8E-01	Selenium (Se)	<1.8E-02
Chromium (Cr)	4.9E+00	Sulfate (SO_4)	8.4E+00
Copper (Cu)	1.3E+01	Strontium (Sr)	3.5E+00
Fluoride (F)	<3.2E-01	Thorium (Th)	6.1E+02
Iron (Fe)	2.6E+03	Uranium (U)	1.4E+01
Mercury (Hg)	5.9E+03	Zinc (Zn)	2.4E+00
Iodine (I)	1.9E-01	Zirconium (Zr)	1.1E+01
Manganese (Mn)	1.1E+02		

[SRR-CWDA-2015-00075]

Table 4.8-2: Final Tank 12H Residuals Radionuclide Inventory

Analyte	Tank 12H Final Inventory (2015) (Ci)	Tank 12H Final Inventory (2032) (Ci)	Analyte	Tank 12H Final Inventory (2015) (Ci)	Tank 12H Final Inventory (2032) (Ci)
Am-241	1.3E+02	1.3E+02	Pu-240	1.7E+01	1.6E+01
Am-242m	3.2E-02	3.0E-02	Pu-241	2.3E+02	1.0E+02
Am-243	1.6E-01	1.6E-01	Ra-226	<2.9E-03	<2.9E-03
Ba-137m[a]	8.7E+01	5.8E+01	Ra-228	4.9E-02	6.1E-03
C-14	<3.2E-03	<3.2E-03	Sn-126	1.4E-01	1.4E-01
Cm-243	<7.7E-02	<5.1E-02	Sr-90	1.2E+05	8.1E+04
Cm-244	<2.1E+00	<1.1E+00	Tc-99	7.2E-02	7.2E-02
Cm-245	3.0E-04	3.0E-04	Th-229	<1.3E-03	<1.3E-03
Cs-135	<6.3E-05	<6.3E-05	Th-230	<2.2E-03	<2.2E-03
Cs-137	9.1E+01	6.1E+01	Th-232	6.6E-02	6.6E-02
I-129	3.8E-02	3.8E-02	U-232	2.6E-02	2.2E-02
Nb-94	<2.7E-03	<2.7E-03	U-233	<2.0E-01	<2.0E-01
Ni-59	2.0E+00	2.0E+00	U-234	5.5E-02	5.5E-02
Ni-63	1.9E+02	1.7E+02	U-235	3.4E-04	3.4E-04
Np-237	1.6E-01	1.6E-01	U-238	5.9E-03	5.9E-03
Pa-231	1.5E-02	1.5E-02	Y-90[b]	1.2E+05	8.1E+04
Pu-238	1.0E+03	8.8E+02	Zr-93	4.0E+00	4.0E+00
Pu-239	4.3E+01	4.3E+01			

[SRR-CWDA-2015-00075]

[a] Based on equilibrium relationship with Cs-137

[b] Based on equilibrium relationship with Sr-90

5.0 TANK 12H PERFORMANCE EVALUATION

Introduction

Because characterization of the Tank 12H residuals was still underway when the Tank 12H CM was developed, the results of the Tank 16H SA were used to evaluate the potential Tank 12H impact on the HTF performance objectives shown in the Tank 12H CM.

The Tank 16H SA modeling used:

- A forecasted residuals inventory for Tank 12H
- The final residuals inventory for Tank 16H
- Where applicable, updated residuals inventories for the remaining HTF waste tanks and ancillary structures [SRR-CWDA-2010-00023]
- The same deterministic (PORFLOW) and probabilistic (GoldSim) models developed for the HTF PA [SRR-CWDA-2010-00128] and, where applicable, modified inventory segmentation and updated distribution coefficients

The potential impacts were presented in Section 5.0 of the Tank 12H CM. [SRR-CWDA-2014-00086] Now that the Tank 12H residual materials have been characterized, an SA has been performed to compare the impacts against the performance objectives using the actual Tank 12H inventory. The results and impacts to the performance objectives are presented and discussed in the Tank 12H SA. [SRR-CWDA-2015-00073] This CMA presents and discusses only the differences between the Tank 12H CM performance evaluation using the forecasted inventory and the Tank 12H SA using the final inventory values.

5.1 Tank 12H Forecasted Versus Final Inventories

Tables 5.1-1 and 5.1-2 show the differences between the forecasted and final Tank 12H radionuclide and chemical inventories. The nine constituents with higher final inventories than those in the forecasted inventories were: I-129, Pa-231, Th-232, U-232, Zr-93, Ag, Hg, Co, and Se.

5.2 The H-Tank Farm Analysis of Performance

As part of the Tank 12H RFS process, the final residuals inventory determined for Tank 12H was compared with the forecasted Tank 12H inventory used for the Tank 16H SA Base Case modeling to determine and evaluate any changes. GoldSim modeling runs were performed using the final residuals inventory to identify the impacts of any changed constituent concentrations on the HTF groundwater peak total effective dose equivalent (TEDE). The Tank 12H CMA uses dose results from the Tank 12H SA, which were calculated using the HTF GoldSim model (described in Section 6.2 of the Tank 12 SA). The Tank 12H CM used dose results from the Tank 16H SA, that were calculated using the HTF PORFLOW model. As discussed in Section 5.6.2 of the HTF PA, the HTF PORFLOW Model is a 3-D flow and transport model designed to simulate the fate and transport of contaminants released from the HTF. The HTF GoldSim Model is a 1-D abstraction of the HTF PORFLOW Model which can also simulate contaminant transport from the HTF. The two models have been benchmarked to ensure the validity of the GoldSim abstraction and provide confidence that the GoldSim results approximate the results of the HTF PORFLOW Model. The full evaluation results are documented in the Tank 12H SA. [SRR-CWDA-2015-00073]

The HTF analysis of performance information presented in Section 4.0 of the HTF PA and Section 6.3 of the Tank 16H SA is not impacted by the new Tank 12H characterization data. [SRR-CWDA-2010-00128, SRR-CWDA-2015-00073] The Integrated Conceptual Model (ICM) used in the HTF PA and Tank 16H SA is not affected by the final Tank 12H characterization data and was not revised. The HTF GoldSim Model was updated, but no changes were made to the ICM used in the HTF GoldSim Model.

Table 5.1-1: Tank 12H Radionuclide Inventories

Analyte	Tank 12H Forecasted Inventory (2032) (Ci)	Tank 12H Final Inventory (2032)(Ci)	Analyte	Tank 12H Forecasted Inventory (2032) (Ci)	Tank 12H Final Inventory (2032)(Ci)
Am-241	7.0E+02	1.3E+02	Pu-240	3.9E+02	1.6E+01
Am-242m	1.0E+00	3.0E-02	Pu-241	2.5E+03	1.0E+02
Am-243	3.0E+00	1.6E-01	Ra-226	2.1E-02	2.9E-03
Ba-137m[a]	2.4E+03	5.8E+01	Ra-228	2.1E+00	6.1E-03
C-14	1.0E+00	3.2E-03	Sn-126	4.6E+00	1.4E-01
Cm-243	1.0E+00	5.1E-02	Sr-90	1.3E+05	8.1E+04
Cm-244	2.0E+01	1.1E+00	Tc-99	1.2E+01	7.2E-02
Cm-245	1.0E+00	3.0E-04	Th-229	2.1E-03	1.3E-03
Cs-135	5.4E-03	6.3E-05	Th-230	2.1E-02	2.2E-03
Cs-137	2.5E+03	6.1E+01	**Th-232**	5.5E-02	**6.6E-02**
I-129	2.6E-02	**3.8E-02**	**U-232**	2.1E-02	**2.2E-02**
Nb-94	1.1E-01	2.7E-03	U-233	3.3E+00	2.0E-01
Ni-59	8.6E+00	2.0E+00	U-234	1.7E+00	5.5E-02
Ni-63	6.3E+02	1.7E+02	U-235	2.1E-02	3.4E-04
Np-237	7.2E-01	1.6E-01	U-238	1.8E-01	5.9E-03
Pa-231	2.1E-03	**1.5E-02**	Y-90[b]	1.3E+05	8.1E+04
Pu-238	9.8E+03	8.8E+02	**Zr-93**	4.0E-01	**4.0E+00**
Pu-239	3.9E+02	4.3E+01			

[SRR-CWDA-2015-00075]

Note: Bold numbers indicate values higher than those assigned to the Tank 16H SA inventory. Nonbolded numbers indicate values lower than those assigned in the Tank 16H SA inventory.

[a] Based on equilibrium relationship with Cs-137

[b] Based on equilibrium relationship with Sr-90

Table 5.1-2: Tank 12H Chemical Inventories

Analyte	Tank 12H Forecasted Inventory (kg)	Tank 12H Final Inventory (kg)
Silver (Ag)	5.3E+00	**7.1E+00**
Aluminum (Al)	2.5E+03	6.7E+02
Arsenic (As)	1.4E-01	1.6E-02
Boron (B)	3.6E+01	9.6E+00
Barium (Ba)	2.3E+01	4.5E+00
Cadmium (Cd)	1.5E+01	2.6E-01
Chloride (Cl)	1.0E+02	1.5E+00
Cobalt (Co)	2.1E-01	**4.8E-01**
Chromium (Cr)	2.4E+01	4.9E+00
Copper (Cu)	1.6E+01	1.3E+01
Fluoride (F)	1.4E+01	3.2E-01
Iron (Fe)	3.0E+03	2.6E+03
Mercury (Hg)	4.5E+03	**5.9E+03**
Iodine (I)	5.0E-01	1.9E-01
Manganese (Mn)	3.2E+03	1.1E+02
Molybdenum (Mo)	3.6E+01	7.4E-01
Nickel (Ni)	3.9E+02	7.4E+01
Nitrite (NO_2)	3.5E+03	9.1E-01
Nitrate (NO_3)	3.2E+02	2.5E+00
Lead (Pb)	5.0E+01	7.1E+00
Phosphate (PO_4)	8.8E+00	3.2E-01
Antimony (Sb)	6.0E+00	1.5E+00
Selenium (Se)	1.1E-02	**1.8E-02**
Sulfate (SO_4)	4.4E+01	8.4E+00
Strontium (Sr)	1.1E+01	3.5E+00
Uranium (U)	4.0E+02	1.4E+01
Zinc (Zn)	6.0E+00	2.4E+00

[SRR-CWDA-2015-00075]

Note: Bold numbers indicate values higher than those assigned to the Tank 16H SA inventory. Nonbolded numbers indicate values lower than those assigned in the Tank 16H SA inventory.

5.3 H-Tank Farm Results of Analysis

The Tank 16H SA evaluated the impact of updated HTF inventories, including the Tank 12H forecasted inventory, on various member of the public (MOP) dose assessments. [SRR-CWDA-2014-00106] As mentioned in Section 5.1, the final and forecasted Tank 12H inventory comparison showed that only nine constituents were not bounded by the forecasted inventory.

Figure 5.3-1 compares the peak groundwater dose (e.g., TEDE) for all HTF sources at the HTF 100-meter assessment point determined in the Tank 16H SA (using the forecasted Tank 12H inventory) versus the peak groundwater dose for all HTF sources determined in the Tank 12H SA (using the final Tank 12H inventory). Figure 5.3-1 demonstrates the general impact of the

higher I-129, Pa-231, Th-232, U-232, and Zr-93 in the final inventory. Figure 5.3-2 compares the doses associated with the final Tank 12H inventory (documented in the Tank 12H SA), against the TEDE doses associated with the forecasted Tank 12H inventory (documented in the Tank 16H SA). These MOP doses were calculated for the HTF Base Case using the HTF GoldSim model. Figures 5.3-1 and 5.3-2 illustrate that the HTF MOP TEDE peak groundwater dose is primarily driven by the Tank 12H inventory.

Figure 5.3-1: MOP Peak Groundwater Pathway TEDE at HTF 100-Meter Assessment Point Within 20,000 Years Showing All HTF Sources

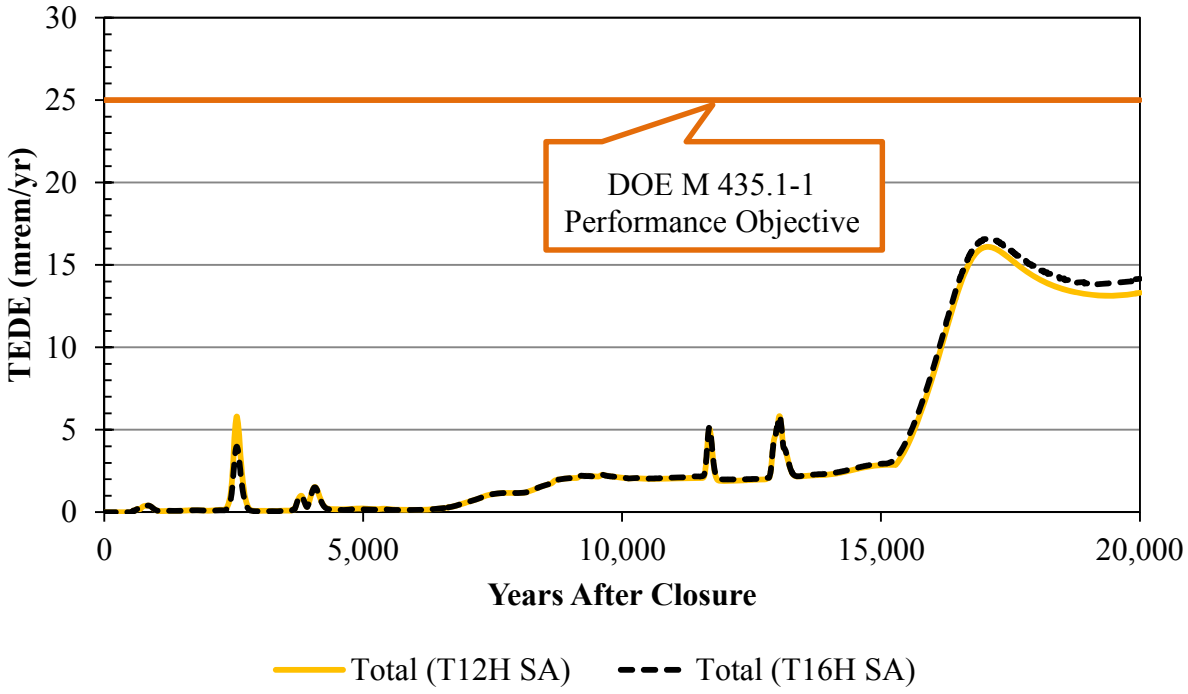
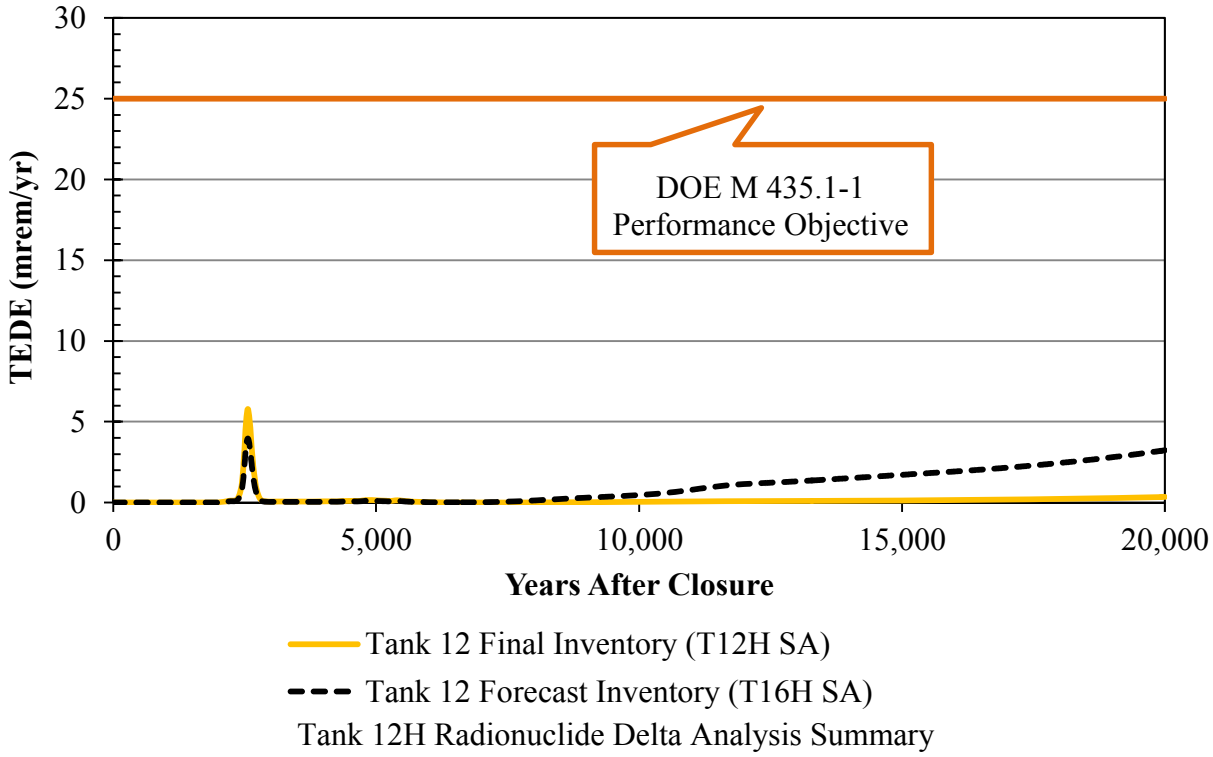


Figure 5.3-2: MOP Peak Groundwater Pathway TEDE at HTF 100-Meter Assessment Point Within 20,000 Years Showing the Tank 12H Only Contribution



The increased I-129 inventory produces the greatest impact on the groundwater pathway doses. The minimal impacts associated with the increased Pa-231, Th-232, U-232, and Zr-93 inventories, and other exposure pathways are discussed in the Tank 12H SA. [SRR-CWDA-2015-00073]

100-Meter (Water from Well) Groundwater Pathways Doses

The HTF peak 100-meter groundwater pathway doses (e.g., TEDE) in the 1,000-year DOE Compliance Period are primarily associated with Tc-99, not with I-129 or the increased Pa-231, Th-232, U-232, and Zr-93 concentrations in the final Tank 12H inventory. Therefore, the 1,000 year peak dose result of 0.2 mrem/yr remains unchanged (Figure 5.3-1).

The HTF peak 100-meter groundwater pathway doses in 10,000 years are the model sectors that are closest to the Type I and Type II tanks. These are the only waste tanks projected in the HTF PA Base Case to have their liners degraded at the time of HTF closure.

The I-129 concentration increased 46% above the forecasted inventory value and causes the HTF peak dose to also increase approximately 46% from 4.1 mrem/yr to approximately 6.0 mrem/yr. The peak dose is at year 2,610 and is dominated by I-129.

The peak groundwater radionuclide concentrations within the 1,000-year DOE Compliance Period were calculated in the Tank 16H SA and no contaminants were above the respective maximum contaminant level (MCL) or preliminary remediation goal (PRG) values at the 1-meter assessment boundary. The peak groundwater radionuclide concentrations are impacted by the inventory increases, with the HTF peak gross beta-gamma concentration and peak gross alpha

concentration both affected. The HTF peak gross beta-gamma and peak gross alpha concentrations both potentially affected (Tables 5.3-1 and 5.3-2).

The 1,000-year HTF peak gross beta-gamma concentration presented in Table 5.3-1 is unchanged from the Tank 12H CM based on the conservative assumption that the I-129 contribution of 4.9E-04 mrem/yr (Tank 16H SA Appendix D) increases 46% and the Tc-99 contribution of 3.9E-01 mrem/yr (Tank 16H SA Appendix D) remains unchanged. The increase in I-129 is conservatively based on the 46% increase in the Tank 12H I-129 inventory. The unchanged Tc-99 contribution assumption is based on the fact that the Tank 12H Tc-99 inventory decreased and the Tc-99 inventory in other HTF tanks is unchanged. The Zr-93/Nb-93m contribution remains negligible within 1,000 years as documented in the Tank 12H SA (Section 6.4.4).

The 10,000-year HTF peak gross beta-gamma concentration presented in Table 5.3-2 is increased from the Tank 12H CM based on the conservative assumption that the I-129 contribution of 8.4 mrem/yr (Tank 16H SA Appendix D) increases 46% and the Tc-99 contribution of 2.6 mrem/yr (Tank 16H SA Appendix D) remains unchanged. The increase in I-129 is based on the 46% increase in the Tank 12H I-129 inventory. The unchanged Tc-99 contribution assumption is based on the fact that the Tank 12H Tc-99 inventory decreased and the Tc-99 inventory in other HTF tanks is unchanged. The Zr-93/Nb-93m contribution remains negligible within 10,000 years as documented in the Tank 12H SA (Section 6.4.4). The calculated concentrations associated with I-129 used in these MCL assessments are conservative, since the entire iodine inventory was modeled in the Base Case as being instantaneously soluble. As discussed in Section 6.4.1 of the Tank 16H SA, estimates of solubility controls on I-129 suggest the possibility that Ag or Hg in the residual waste can limit the release of I-129 under certain conditions.

The 1,000-year (0.25 pCi/L) and 10,000-year (4.8 pCi/L) HTF peak gross alpha concentrations (Tables 5.3-1 and 5.3-2 respectively) are unchanged from the Tank 12H CM concentrations and remain below the 15 pCi/L alpha MCL. The three radionuclides with increased Tank 12H inventories that contribute to the alpha concentration (Pa-231, Th-232, and U-232) all had negligible concentration increases in 10,000 years, as shown in the Tank 12H SA (Sections 6.4.2 and 6.4.3).

Table 5.3-1: Tank 12H Groundwater Dose and Concentrations at 100-meters in 1,000 Years

1,000 years			
Analyte	**Units**	**Maximum Contaminant Level[a]**	**100-meter Dose or Concentration**
Beta-gamma dose[b]	mrem/yr	4	4.0E-01
Alpha concentration	pCi/L	15	2.5E-01
Silver (Ag)	µg/L	100	1.7E-03
Cobalt (Co)	µg/L	NA	1.8E-10
Manganese (Mn)	µg/L	50	1.3E-03
Mercury (Hg)	µg/L	2	3.9E-25
Selenium (Se)	µg/L	50	1.4E-29

[a] SCDHEC R.61-58

[b] The state drinking water standard for beta particle and photon radioactivity is specified in the South Carolina State Primary Drinking Water Regulation which states that "The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water must not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year (mrem/year)." [SCDHEC R.61-58] This total body or organ dose equivalent comparison to the standard is calculated on the basis of two (2) liters per day drinking water intake. Rather than using the 168 hour data listed in *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, NBS (National Bureau of Standards) Handbook 69 as amended August 1963, U.S. Department of Commerce*, the values are calculated using the most current Dose Conversion Factors (DCFs) from *Dose Calculation Methodology for Liquid Waste Performance Assessments at the Savannah River Site* (SRR-CWDA-2013-00058). Because two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ is calculated. The calculated individual radionuclide concentrations are provided in the Tank 16H SA. [SRR-CWDA-2014-00106]

Table 5.3-2: Tank 12H Groundwater Dose and Concentrations at 100-meters in 10,000 Years

10,000 years			
Analyte	**Concentration**	**Maximum Contaminant Level[a]**	**100 meter Dose or Concentration**
Beta-gamma dose[b]	mrem/yr	4	1.5E+01
Alpha concentration	pCi/L	15	4.8E+00
Silver (Ag)	µg/L	100	5.1E-01
Cobalt (Co)	µg/L	NA	2.5E-02
Manganese (Mn)	µg/L	50	4.5E+01
Mercury (Hg)	µg/L	2	8.7E-09
Selenium (Se)	µg/L	50	2.5E-13

[a] SCDHEC R.61-58

[b] The state drinking water standard for beta particle and photon radioactivity is specified in the South Carolina State Primary Drinking Water Regulation which states that "The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water must not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year (mrem/year)." [SCDHEC R.61-58] This total body or organ dose equivalent comparison to the standard is calculated on the basis of two (2) liters per day drinking water intake. Rather than using the 168 hour data listed in *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, NBS (National Bureau of Standards) Handbook 69 as amended August 1963, U.S. Department of Commerce*, the values are calculated using the most current DCFs from *Dose Calculation Methodology for Liquid Waste Performance Assessments at the Savannah River Site* (SRR-CWDA-2013-00058). Because two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ is calculated. The calculated individual radionuclide concentrations are provided in the Tank 16H SA. [SRR-CWDA-2014-00106]

Water at the Stream Seepline

The peak groundwater pathway MOP dose in 10,000 years is at the Fourmile Branch (FMB) stream seepline approximately 1,200 meters southwest of Tank 12H. The peak groundwater pathway MOP dose at the FMB stream seepline in 1,000 years is 0.02 mrem/yr at year 740, primarily due to Tc-99. Because the Tank 12H I-129 inventory could increase by 46%, the peak groundwater pathway MOP dose in 10,000 years would increase no more than 46% from the 0.03 mrem/yr peak modeled in the Tank 16H SA to 0.04 mrem/yr. The peak dose is at year 3,950 and is dominated by I-129.

5.3.1 Tank 12H Chemical Inventory Analysis Summary

The chemical contaminant release models used to calculate HTF peak groundwater concentrations in the Tank 16H SA included retardation due to sorption (using elemental K_d values) but did not include waste release modeling using solubility limits. Since the HTF concentration calculations were not based on solubility limits, changes in Tank 12H inventory would at worst have a directly proportional impact on HTF peak groundwater concentrations.

The calculated peak groundwater chemical concentrations provide reasonable assurance that compliance is maintained with the state drinking water requirements, as applicable per DOE M 435.1-1 and the *Industrial Wastewater General Closure Plan for H-Area Waste Tank Systems*. [SRR-CWDA-2011-00022] The peak groundwater chemical concentrations within 1,000 years for the chemicals of concern were calculated in the Tank 16H SA and all were shown to be less than the MCL or regional screening level (RSL) concentration at a distance of one meter from HTF. As discussed in the Tank 12H SA, these results are not affected by the new characterization information.

Tables 5.3-1 and 5.3-2 present the peak HTF groundwater chemical concentration results for Ag, Co, Hg, and Se at 100-meters within 1,000-year and 10,000-years. The chemical concentrations of Ag, Co, Hg, and Se are conservatively assumed to increase in direct proportion to the percentage increase in their associated Tank 12H inventories (approximately 34%, 129%, 30%, and 64% respectively). Based on the groundwater concentrations calculated for these chemicals using the HTF GoldSim model (shown in Figures 5.3-3 and 5.3-4 and documented in Section 6.5.6 of the Tank 12H SA), the actual increase in groundwater concentrations is expected to be much less than the inventory percentage increases.

The Mn inventory in Tank 12H is 108 kg, a 97% decrease from the Tank 12H forecasted inventory (3,200 kg) used in calculating the Mn concentration for the Tank 12H CM. The peak HTF Mn concentration within 1,000-years (Table 5.3-1) is assumed unchanged. The unchanged Mn contribution assumption is based on the fact that the Tank 12H Mn inventory decreased and the Mn inventory in other HTF tanks is unchanged. Assuming the Mn concentration in 1,000 years is unchanged is conservative since the peak concentration would decrease if it were only associated with the Mn inventory in Tank 12H. Within 10,000 years, the Mn concentration at 100 meters (250 µg/L) calculated based on 3,200 kg was above the 50 µg/L Mn MCL due to the significant Tank 12H Mn forecasted inventory. The Tank 12H Mn inventory decrease results in the peak HTF manganese concentration within 10,000 years (presented in Table 5.3-2) decreasing by over 80%, which would result in it being below the 50 µg/L Mn MCL.

Figure 5.3-3: 1-Meter Peak Groundwater Concentrations for Silver, Cobalt, Mercury, and Selenium for all HTF Sources

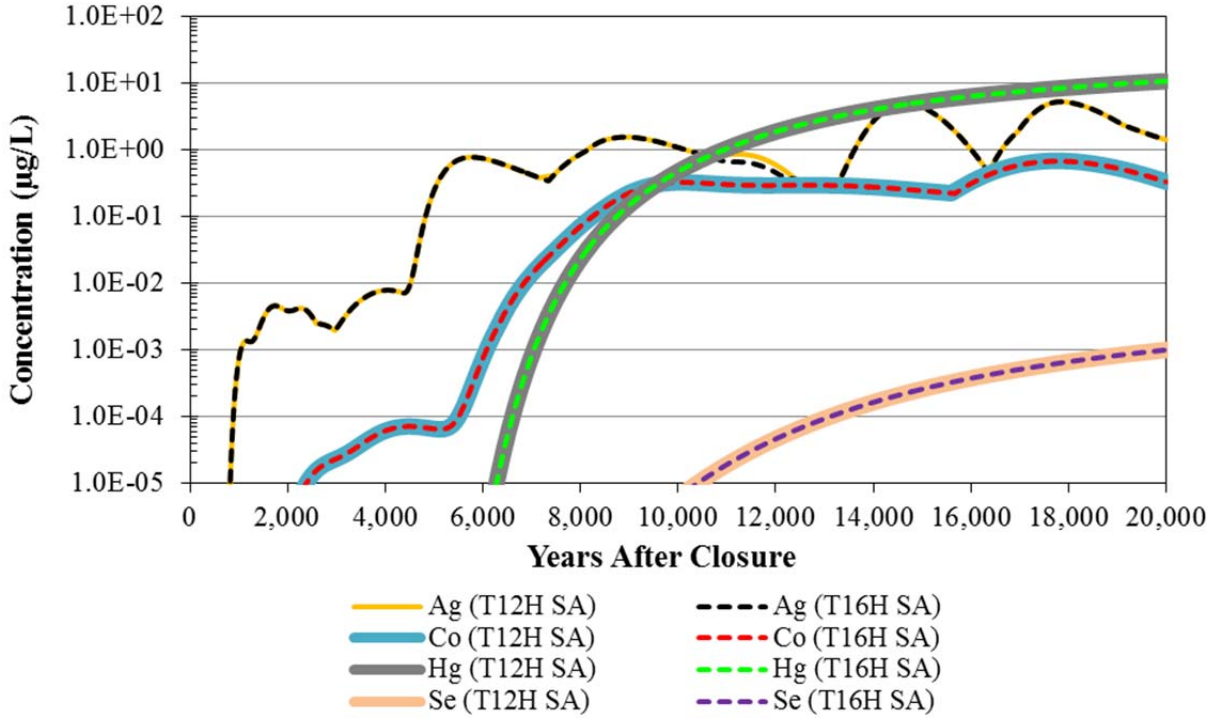
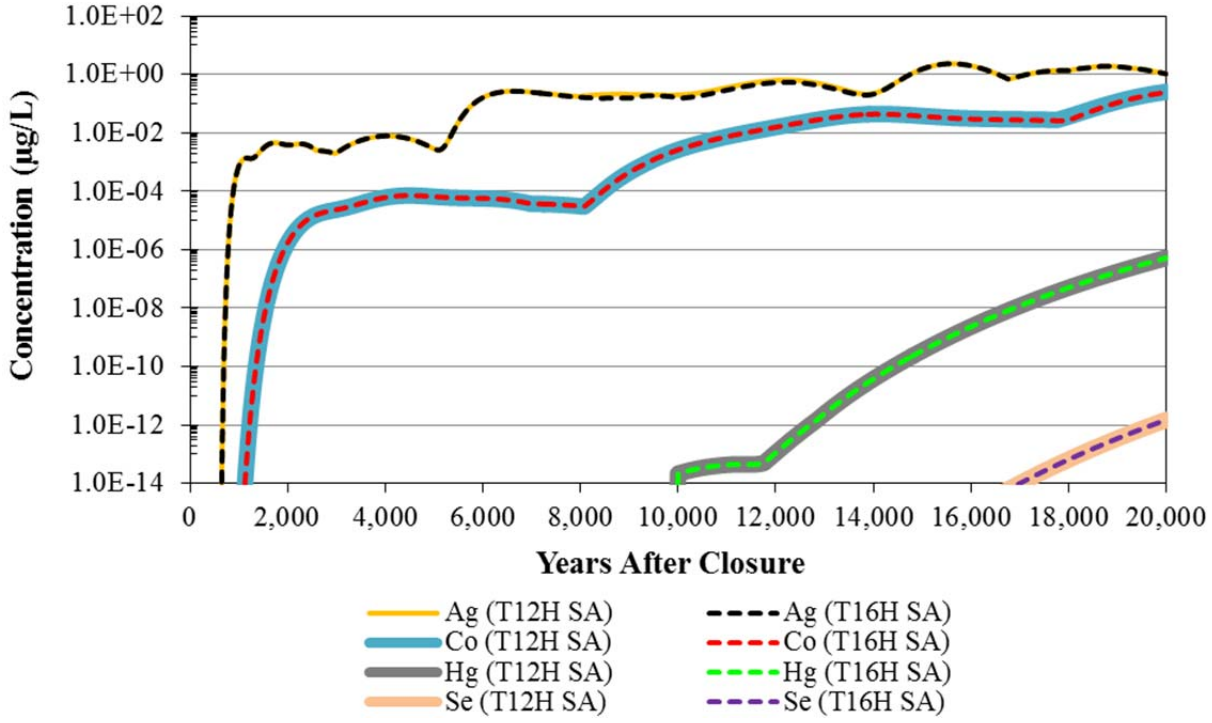


Figure 5.3-4: 100-Meter Peak Groundwater Concentrations for Silver, Cobalt, Mercury, and Selenium for all HTF Sources



6.0 ASSESSMENT OR THE IMPACT OF DEPLOYING ADDITIONAL REMOVAL TECHNOLOGY

See the Tank 12H CM Section 6.0 (pages 78-85)

7.0 WASTE TANK SYSTEM ISOLATION PROCESS AND STABILIZATION STRATEGY

See the Tank 12H CM Section 7.0 (pages 86-94)

8.0 MAINTENANCE AND MONITORING PLANS

See the Tank 12H CM Section 8.0 (page 95)

9.0 CONCLUSION

The conclusions reached in the Tank 12H CM are not changed. This section summarizes updated information.

- Visual Observation in the Tank Primary – For the Tank 12H primary tank, the determination to cease waste removal activities was primarily based on visual observation. Visual inspections inside the primary tank were performed using remotely operated cameras suspended from waste tank risers and on-board cameras mounted on robotic crawlers used during sampling. These visual observations showed there was a significant reduction in residual material volume as a result of the waste removal efforts. Figure 6.0-1 shows the Tank 12H primary taken in August 2015.

Figure 9.0-1: Panoramic View of the Tank 12H Primary Tank After Waste Removal

- As explained in the CM, it is not technically practicable from an engineering perspective to continue with active waste removal activities
- Human Health and Environment Impacts – The Tank 12H residuals were sampled to determine the final tank inventory. The Tank 12H SA evaluated the fate and transport GoldSim modeling results using the actual Tank 12H inventories. The comparison showed there is reasonable assurance that groundwater concentrations derived from residual contamination in the HTF tanks and ancillary structures will meet the

performance objectives. These modeling results provide assurance that human health and the environment will continue to be protected after the HTF waste tank systems have been stabilized with grout and removed from service. [SRR-CWDA-2015-00073]

- Isolation Strategy – *No change from the Tank 12H CM.*
- Stabilization – *No change from the Tank 12H CM.*
- Maintenance and Monitoring – *No change from the Tank 12H CM.*

DOE has determined that after completion of this CMA, all HTF GCP requirements have been met to proceed with removing Tank 12H from service. DOE is ready to stabilize the waste tank with grout. Approval of this CMA by SCDHEC signifies State acceptance of the proposed DOE closure activities for Tank 12H and State concurrence that waste removal activities for Tank 12H can cease. In accordance with the FFA, EPA will provide concurrence that waste removal activities may cease. Following stabilization, DOE will submit a Final Configuration Report for Tank 12H to SCDHEC with certification that the RFS activities have been performed in accordance with the HTF GCP, the CM and CMA.

Based on this approach, DOE has determined that residual material has been removed from Tank 12H to the extent technically practicable from an engineering perspective and is ready to proceed to isolation and stabilization activities summarized in Section 7.0 of the Tank 12H CM. Based on the information provided in the CM, CMA and supporting documents, it may be concluded that (1) there is reasonable assurance that, at the time of final FFA corrective/remedial actions, groundwater concentrations derived from residual contamination in the waste tanks and ancillary structures will be less than the South Carolina state drinking water standards and (2) further residual removal is not technically practicable from an engineering perspective. DOE has validated this conclusion in this CMA using the results of the Tank 12H SA and determined that human health and the environment will continue to be protected after the HTF waste tank systems have been stabilized with grout and removed from service.

10.0 REFERENCES

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APPENDIX A: WASTE TANK SYSTEM TRACKING

Future closure of the waste tanks and ancillary structures will be conducted in such a way that structures will be included in CMs when determined that it is practical to remove the structures from service simultaneously with the waste tanks and there is no longer a need for the ancillary structures to manage waste in tanks that are still in service. The ancillary structures to be closed as part of the HTF are listed in Table A-1. As CMs are developed and approved, Table A-1 will be updated to include the document number and date of RFS for each of the ancillary structures listed in Permit #17,424-IW (DHEC_01-25-1993) to ensure that all waste tanks and ancillary structures have been addressed.

Note: The Closure Module Addendum (CMA) has been added for Tank 12 since it is integral to the RFS.

Table A-1: HTF Waste Systems Tracking

Waste Tank System	CM Document Number	Date of RFS
Tank 9		
Tank 10		
Tank 11		
Tank 12	SRR-CWDA-2014-00086 CMA: SRR-CWDA-2015-00074	
Tank 13		
Tank 14		
Tank 15		
Tank 16	SRR-CWDA-2013-00091	10/02/2015
Tank 21		
Tank 22		
Tank 23		
Tank 24		
Tank 29		
Tank 30		
Tank 31		
Tank 32		
Tank 35		
Tank 36		
Tank 37		
Tank 38		
Tank 39		
Tank 40		
Tank 41		
Tank 42		
Tank 43		
Tank 48		
Tank 49		
Tank 50		
Tank 51		

Table A-1: HTF Waste Systems Tracking (Continued)

Waste Tank System	CM Document Number	Date of RFS
242-H Evaporator Pot		
Mercury Collection Tank		
Cesium Removal Column Pump Tank		
Overheads Tank, North		
Overheads Tank, South		
242-16H Evaporator Pot		
Mercury Collection Tank		
Cesium Removal Column Pump Tank		
Overheads Tank, North		
Overheads Tank, South		
242-25H Evaporator Pot		
Mercury Collection Tank		
Cesium Removal Column Pump Tank		
Overheads Tank, North		
Overheads Tank, South		
HPP-1		
HPP-2 and HPT-2		
HPP-3 and HPT-3		
HPP-4 and HPT-4		
HPP-5 and HPT-5		
HPP-6 and HPT-6		
HPP-7 and HPT-7		
HPP-8 and HPT-8		
HPP-9 and HPT-9		
HPP-10 and HPT-10		
Concentrate Transfer System (242-3H)		
Concentrate Transfer System (242-18H)		
HDB-1		
HDB-2		
HDB-3		
HDB-4		
HDB-5		
HDB-6		
HDB-7		
HDB-8		
H-Area Catch Tank		