SRR-CWDA-2014-00086
Revision 0

INDUSTRIAL WASTEWATER CLOSURE MODULE FOR LIQUID WASTE TANK 12H

H-AREA TANK FARM, SAVANNAH RIVER SITE

May 2015

Industrial Wastewater Construction Permit No. 17,424-IW

Prepared by: Savannah River Remediation LLC
Regulatory Management & Administration
Aiken, SC 29808

Prepared for U.S. Department of Energy Under Contract No. DE-AC09-09SR22505

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AEA	Atomic Energy Act of 1954
BOA	Bulk Oxalic Acid
BOAC	Bulk Oxalic Acid Cleaning
BWRE	Bulk Waste Removal Efforts
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHA	Consolidated Hazard Analysis
CM	Closure Module
CMCOC	Contaminant Migration Constituent of Concern
CSR	Chemical Sludge Removal
CTS	Concentrate Transfer System
DCF	Dose Conversion Factor
DOE	United States Department of Energy
DSA	Documented Safety Analysis
DWPF	Defense Waste Processing Facility
EDE	Effective Dose Equivalent
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
FFA	Federal Facility Agreement
FMB	Fourmile Branch
FTF	F-Area Tank Farm
GCP	General Closure Plan
GSA	General Separations Area
HDB	H-Area Diversion Box
HHW	High-Heat Waste
HLLCP	High Liquid Level Conductivity Probe
HM	H-Modified
HRR	Highly Radioactive Radionuclide
HTF	H-Area Tank Farm
ICM	Integrated Conceptual Model
IROD	Interim Record of Decision
IW	Inhibited Water
LTAD	Low Temperature Aluminum Dissolution
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
MOP	Member of the Public
MSR	Mechanical Sludge Removal
NBS	National Bureau of Standards
OA	Oxalic Acid
OU	Operable Unit
PA	Performance Assessment
PP	Pump Pit
PUREX	Plutonium-Uranium Extraction
RCRA	Resource Conservation and Recovery Act

RFS	Removal from Service
RSL	Regional Screening Level
SA	Special Analysis
SB	Sludge Batch
SCDHEC	South Carolina Department of Health and Environmental Control
SDF	Saltstone Disposal Facility
SLP	Slurry Pump
SMP	Submersible Mixer Pump
SPF	Saltstone Production Facility
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
STP	Submersible Transfer Pump
TEDE	Total Effective Dose Equivalent
THOREX	Thorium Extraction
TNX	Training and Experimental Test Facility
UTR	Upper Three Runs
WCS	Waste Characterization System
WTS	Waste Transfer System

EXECUTIVE SUMMARY

The United States Department of Energy (DOE) and the State of South Carolina have developed the *Industrial Wastewater General Closure Plan for H-Area Waste Tank Systems* (SRR-CWDA-2011-00022) to support the removal from service (RFS) of the H-Area Tank Farm (HTF) underground radioactive waste tanks and ancillary structures at the Savannah River Site (SRS). The HTF General Closure Plan (GCP) establishes the protocol by which DOE intends to close HTF waste tank systems at SRS and receive approval from the South Carolina Department of Health and Environmental Control (SCDHEC) following public comment. Specifically, Section 6, *Closure Module Preparation and Approval*, of the HTF GCP outlines the requirements for Closure Module (CM) content, development, and approval. Distinct to Tank 12H, a two-step approach to development and approval of the CM will be used by the DOE resulting in the improvement (i.e., shortening) of the RFS schedule for this tank. The first step is to prepare and obtain conditional SCDHEC approval of this CM which uses forecasted residual inventory information. Coinciding with the preparation and conditional approval of this CM, Tank 12H residual materials sampling and analysis will be conducted and completed. The second step of the process involves presenting the residuals final characterization information in an addendum for approval by SCDHEC. This CM and planned CM addendum support the RFS of underground radioactive waste Tank 12H in the 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 SRS is a Federal facility owned by DOE. Since beginning operations in the early 1950s, uranium and plutonium recovery processes have generated liquid radioactive waste, which is currently stored in underground waste tanks in the F and H Areas at the site. The DOE intends to remove from service all of the waste tanks with priority being given to the old-style waste tanks that do not meet the standards established in Appendix B of the SRS Federal Facility Agreement (FFA). [WSRC-OS-94-42] The FFA has been entered into pursuant to Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Sections 3008(h) and 6001 of the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984 (hereinafter jointly referred to as RCRA) and the Atomic Energy Act of 1954 (AEA), as amended, 42 U.S.C. § 2011.[1] Once SCDHEC, the United States Environmental Protection Agency (EPA), and DOE mutually agree that waste removal from Tank 12H may cease, any residual contaminants will be stabilized through operational closure and then the tank will be removed from service under Construction Permit #17,424-IW. [DHEC_01-25-1993] Subsequently, the stabilized tank will be monitored and maintained in accordance with the requirements of an Interim Record of Decision (IROD) and the SRS RCRA Hazardous Waste Permit, Module VIII, as a solid waste management unit.

The DOE intends to remove from service Tank 12H at 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 RCRA and CERCLA described in the FFA, which will govern the subsequent remediation of the HTF

[1] DOE's submittal of this plan does not waive any DOE claim of jurisdiction over matters reserved to it under the Atomic Energy Act of 1954.

operable unit (OU). These regulations were reviewed at the time of development of this CM and have been verified to have no change since the HTF GCP (SRR-CWDA-2011-00022) was issued. [SCDHEC R.61-82, SCDHEC R.61-67, WSRC-OS-94-42]

A performance assessment (PA) has been developed to assess the long-term fate and transport of residual contaminants in the environment resulting from the RFS of the HTF waste tanks. [SRR-CWDA-2010-00128] Considering the layout of the HTF and the presumed footprint of a potential closure cap (if deemed necessary and appropriate when a final remedy is selected for the HTF OU), it is expected that monitoring wells will be located approximately 100 meters from the HTF boundary (i.e., line of demarcation enclosing the HTF waste tanks). The HTF PA used 100 meters as a point of assessment to predict long-term performance.

This CM describes the processes by which DOE has removed waste from Tank 12H and isolated the tank from the HTF facilities that remain operable. This CM was developed using a forecasted inventory for Tank 12H. The forecasted inventory is based on the identified waste composition and properties, from data in the SRS Waste Characterization System (WCS), process samples obtained and analyzed during waste removal campaigns for Tank 12H, and an estimate of the residual material volume. When final characterization of residual material remaining in the waste tank is completed, the actual Tank 12H residuals inventory will be determined. A Tank 12H Special Analysis (SA) will be performed, comparing the final inventory determination with the forecasted inventory used in this CM. DOE will confirm 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 will be documented in an addendum to this CM. Both this CM and the planned CM addendum will be approved by SCDHEC after public comment.

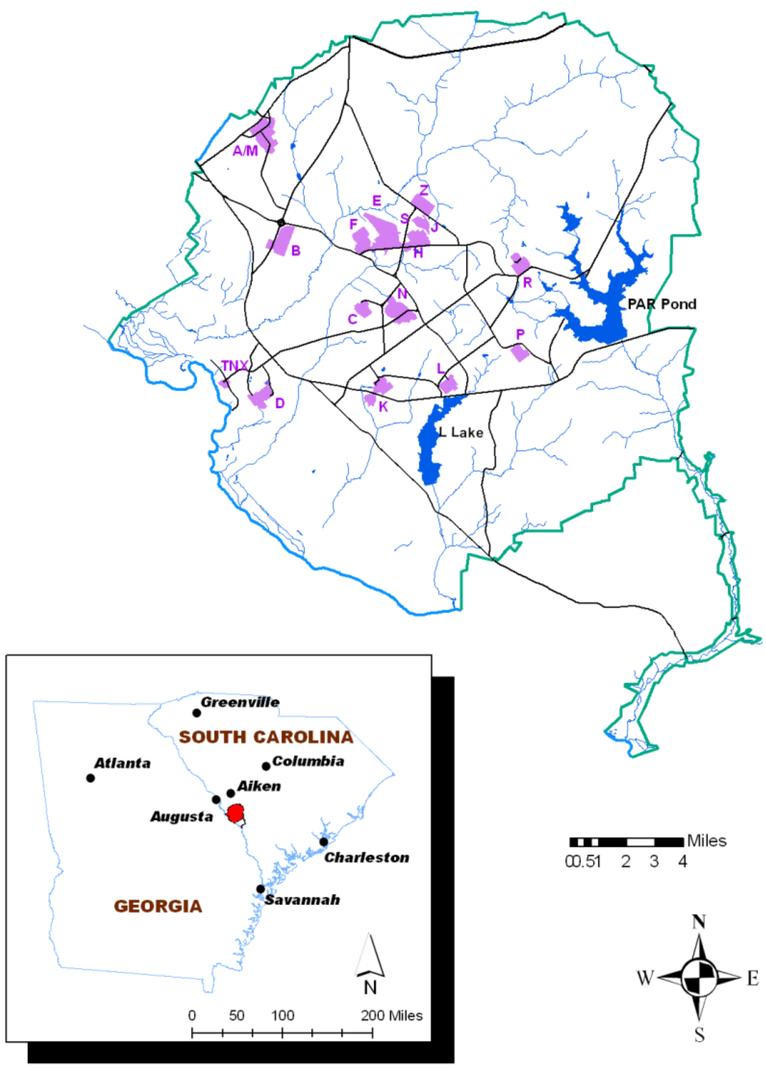
Based on the information provided in this CM and supporting documents, it may be concluded that (1) there is reasonable assurance that, at the time of final FFA corrective/remedial actions, groundwater concentrations derived from residual contamination in the tank and ancillary structures will meet the HTF GCP performance objectives and (2) further waste removal is not technically practicable from an engineering perspective.

Through completion of this CM and the planned CM addendum, 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 approval of this CM and subsequent approval of the CM addendum, 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 and this CM and planned CM addendum.

1.0 INTRODUCTION

Since the early 1950s, the primary mission of SRS had been to produce nuclear materials primarily for national defense and deep space missions. A legacy of the SRS mission was the generation of liquid waste from chemical separations processes in both F and H Areas. Since the beginning of SRS operations, an integrated Liquid Waste System consisting of several facilities designed for the overall processing of liquid waste has evolved. Two of the major components of this system are the HTF and F-Area Tank Farm (FTF) located in H Area and F Area, respectively, which are near the center of the site (Figure 1.0-1). In H Area, neptunium, uranium, and other radionuclides were separated from irradiated fuel and target assemblies using chemical separations processes. The tank farms, which store and process the chemical separations waste, include waste tanks, evaporators, transfer line systems, and other ancillary structures.

Figure 1.0-1: SRS Operational Area Location Map



In support of environmental remediation activities at SRS, DOE, EPA and SCDHEC signed the SRS FFA pursuant to Section 120 of CERCLA, Sections 3008(h) and 6001 of RCRA. The agreement became effective in August 1993. As part of this comprehensive agreement, DOE committed to submit and comply with a schedule to remove from service those liquid radioactive waste tank systems that do not meet the standards set forth in Appendix B of the FFA. Appendix B of the FFA also describes the specific radioactive waste tank systems that are subject to the agreement. [WSRC-OS-94-42]

The HTF GCP establishes the general protocols for removal of the HTF waste tanks and ancillary structures from service in accordance with SCDHEC R.61-82 and SCDHEC R.61-67. This CM and planned addendum provide specific information on the RFS of Tank 12H at the HTF and demonstrate activities have been performed in accordance with requirements set forth in Section 6.0, *Closure Module Preparation and Approval*, of the HTF GCP. [SRR-CWDA-2011-00022] Distinct to Tank 12H, a two-step approach to development and approval of the CM will be used by the DOE resulting in the improvement (i.e., shortening) of the RFS schedule for this tank.

The first step is to prepare and obtain conditional SCDHEC approval, after public comment, of this CM which uses forecasted residual inventory information. Coinciding with the preparation and conditional approval of this CM, Tank 12H residuals sampling and analysis will be conducted and completed. The second step of the process involves presenting the final residual materials characterization information in an addendum for approval by SCDHEC, after public comment. This CM and planned CM addendum support the RFS of underground radioactive waste Tank 12H in the HTF under Construction Permit #17,424-IW. [DHEC_01-25-1993]

This CM contains the following elements:

Introduction (Section 1.0) – Defines the purpose and scope of this CM.

Facility Description (Section 2.0) – Describes Tank 12H and provides a history of the waste tank and the waste types that have been managed in the system.

Waste Removal and Closure Configuration (sections as annotated below) – Describes the process used to remove waste from Tank 12H. These sections focus on the following sub-elements:

- Summary description of the technology selection process for waste removal (Section 3.0)
- Details of the waste removal process (Section 3.0)
- Characterization of residual materials based on forecasted inventory, including forecasted inventory development details (Section 4.0). Final sampling and analysis details will be included in the planned CM addendum.
- Waste tank system isolation process (Section 7.1)
- Description of structures and equipment that are part of this RFS activity including any equipment that will remain in the waste tank at the time of stabilization and RFS (Section 7.2)
- Stabilization strategy including type and characteristics of fill material, as appropriate (Section 7.3)

Performance Evaluation (Section 5.0) – Using the fate and transport model from the HTF PA, including supplemental modeling results from the SA based on the forecasted inventory, information is presented concerning the predicted peak groundwater concentrations.

Waste Removal Analysis (Section 6.0) – An analysis is provided to demonstrate that it is not technically practicable from an engineering perspective to continue with active waste removal activities. This analysis considers technology capabilities, schedule impacts, and relative benefit.

Maintenance and Monitoring (Section 8.0) – This section provides a description of the HTF maintenance and monitoring plans that will be used for the interim period from the time Tank 12H is removed from service until the final closure of the HTF OU.

Conclusion (Section 9.0) – This section provides the conclusion that DOE has demonstrated that 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.

Waste Tank Systems Tracking (Appendix A) – This section tracks the tanks and ancillary structures to ensure that all components of the HTF will be addressed in a CM. This table will be updated in each CM with the RFS date and the document number of the CM that addresses each of the tanks and ancillary structures.

<u>CM Addendum Overview</u>

Once final characterization of residual materials remaining in the waste tank is completed, the final inventory of the Tank 12H residual waste will be determined. A Tank 12H SA will be performed, comparing the final inventory determination with the forecasted inventory used in this CM. DOE will confirm 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 determination and results from the Tank 12H SA will be documented in the planned addendum to this CM.

2.0 FACILITY DESCRIPTION

The HTF site was chosen because of its proximity to the H-Canyon Separations Facility (the major waste generation source), which was located near the center of the site, away from the SRS boundaries. Figure 2.0-1 shows the setting of H Area and HTF within the General Separations Area (GSA).

The HTF occupies 45-acres and consists principally of approximately 74,800 feet of transfer lines, 10 pump pits (PPs) (each has one pump tank except HPP-1 which has none), two concentrate transfer system (CTS) PPs, one catch tank, three evaporators, and 29 waste tanks (Figure 2.0-2). There are four major waste tank types in HTF: Type I tanks with a nominal capacity of 750,000 gallons, Type II tanks with a nominal capacity of 1,070,000 gallons, and Type III/IIIA and Type IV tanks with nominal capacities of 1,300,000 gallons. The differing waste tank types have varying degrees of secondary containment and intra-tank obstructions, such as cooling coils and columns. The HTF design features (e.g., waste tanks, transfer lines, evaporator systems) are discussed in more detail in Sections 3.2.1 and 3.2.2 of the HTF PA. [SRR-CWDA-2010-00128]

The HTF was constructed to receive waste generated by various SRS production, processing, and laboratory facilities. The use of HTF isolated these wastes from the environment, SRS workers, and the public. Facilities are in place to treat the accumulated sludge and salt waste (supernate and saltcake) to enable the management of these wastes within other SRS facilities (i.e., Defense Waste Processing Facility [DWPF] and Saltstone Production Facility [SPF]). These treatment facilities convert the sludge and salt waste to more stable forms suitable for permanent disposal in a Federal repository or the Saltstone Disposal Facility (SDF), as appropriate. The Effluent Treatment Project, located southeast of the HTF, collects and treats wastewater and evaporator overheads from FTF and HTF operations.

Figure 2.0-1: Layout of the GSA

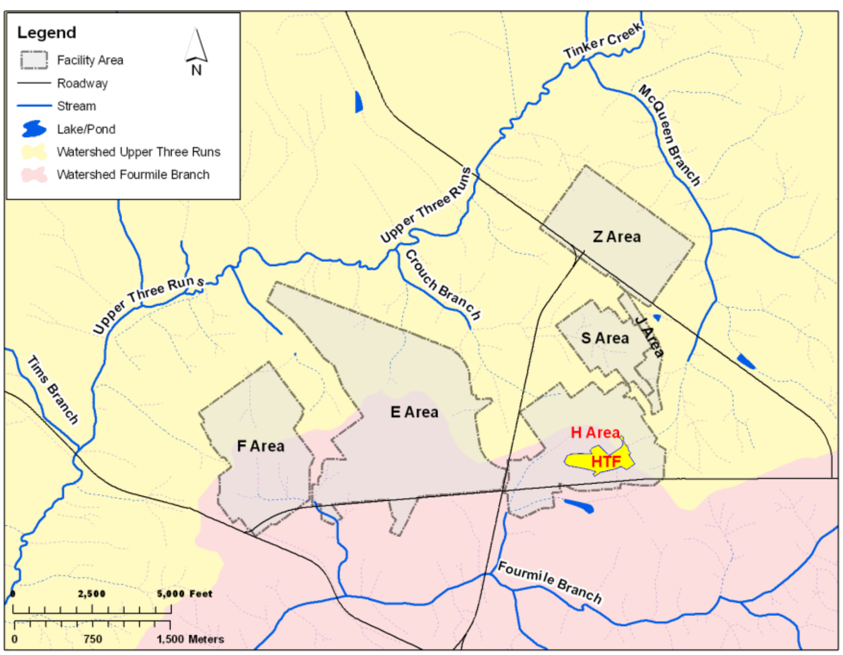
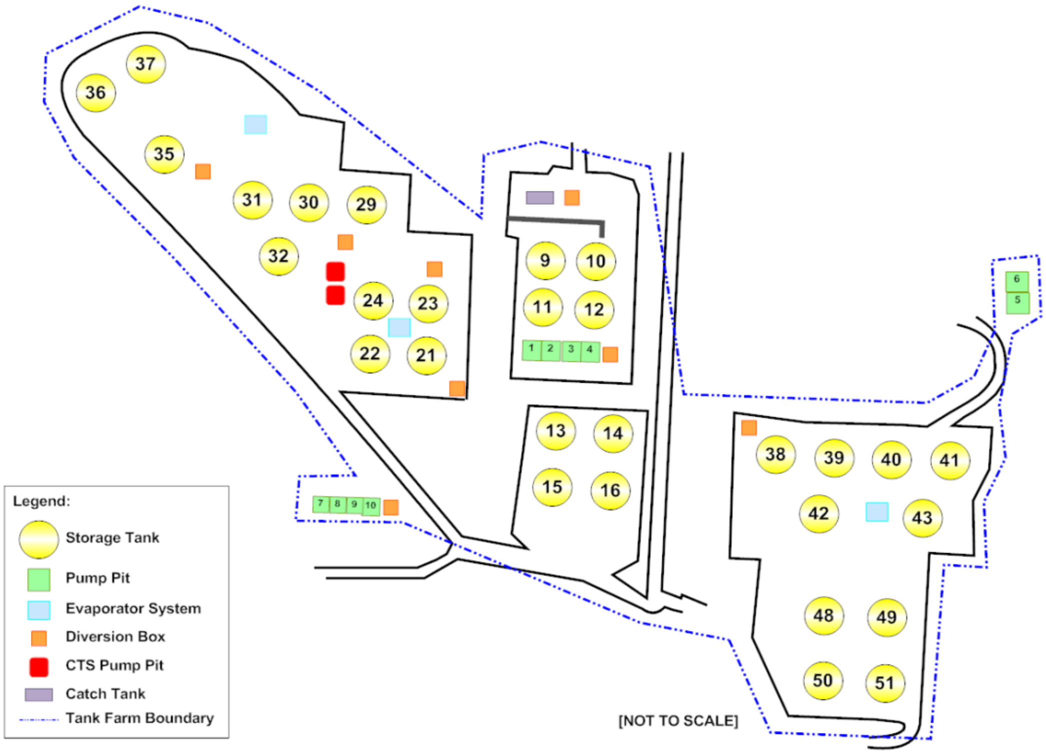


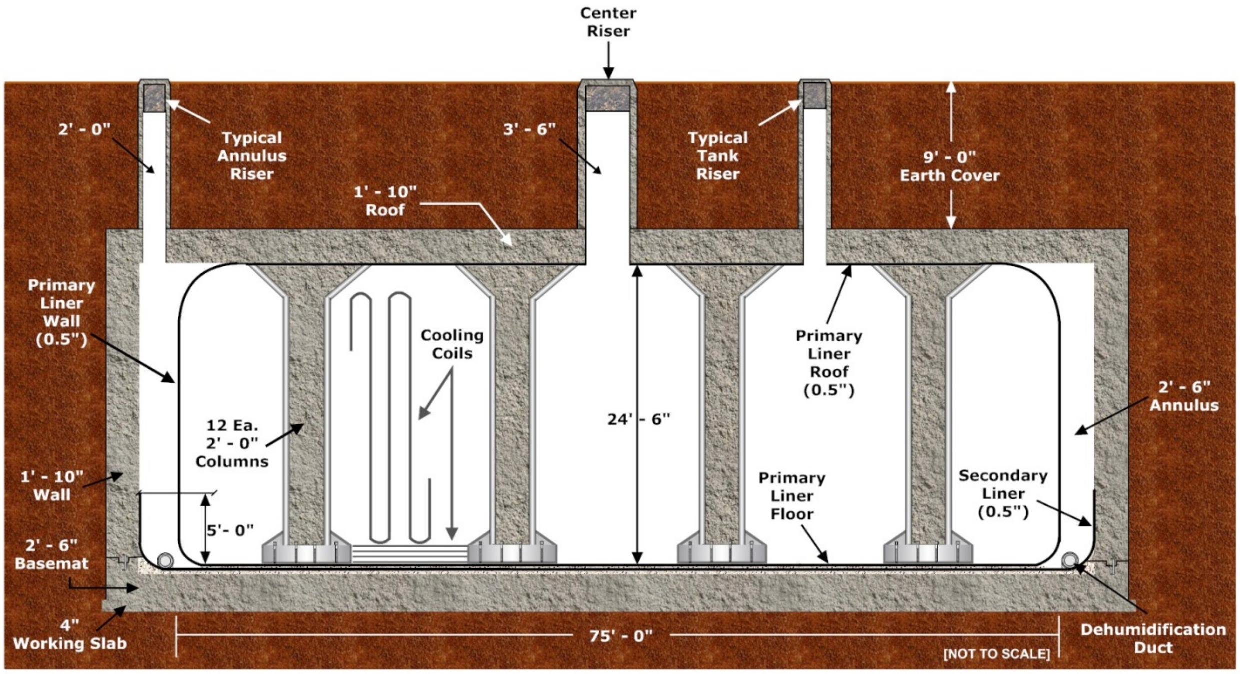
Figure 2.0-2: Layout of HTF



2.1 Tank 12H Design and Construction

Tank 12H is one of four Type I waste tanks (Tanks 9H through 12H) in HTF that were constructed between 1951 and 1953. Type I waste tanks have a primary liner 75 feet in diameter and 24.5 feet high. The nominal operating capacity of a Type I waste tank is 750,000 gallons and the volume inside the primary liner equates to 2,710 gallons per inch (depth). [WSRC-SA-2002-00007, N-ESR-G-00001] Type I waste tanks in HTF are approximately nine feet below grade with the top of the tanks located several feet below the mean water table elevation. The primary liner of Type I waste tanks is made of 0.5-inch thick carbon steel. The 0.5-inch thick carbon steel waste tank top and bottom were joined to the walls with non-stress-relieved welded knuckle plates made of the same material. The carbon steel shell sits inside a 22-inch thick reinforced concrete vault with a 2.5-foot annular space surrounding the primary tank. Lining the bottom of the vault for secondary containment is a 5-foot high 0.5-inch thick carbon steel annulus pan to collect leakage, if any, from the primary tank. The characteristics of typical Type I waste tanks are shown in Figure 2.1-1 and described in more detail in Sections 2.1.1 through 2.1.5. [SRR-CWDA-2010-00128]

Figure 2.1-1: Typical HTF Type I Waste Tank Cross-Section



2.1.1 **Primary and Secondary Liner**

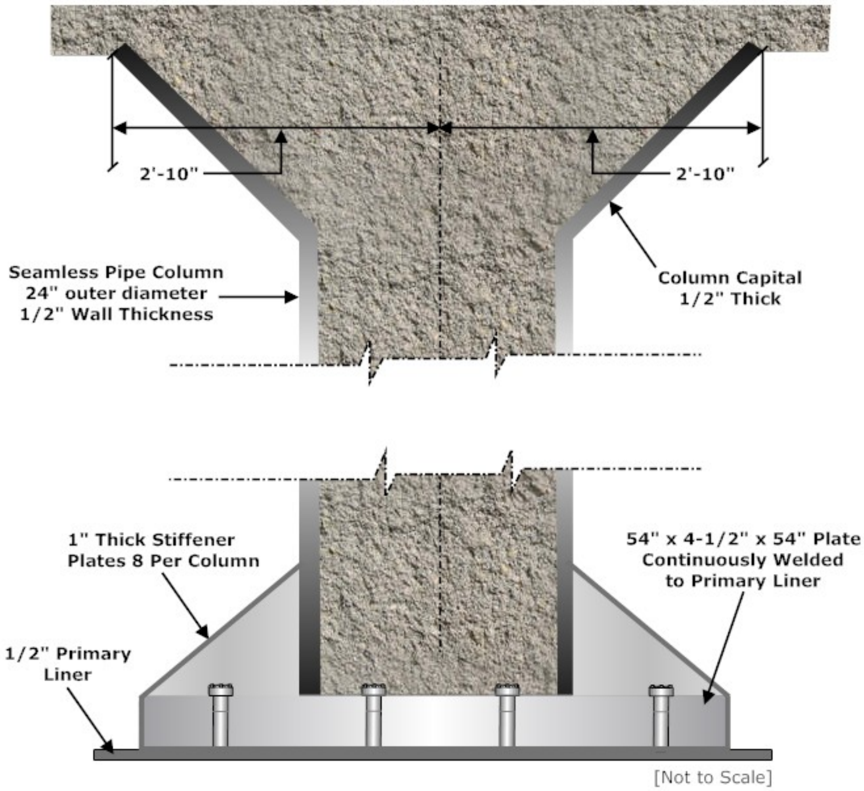
The primary liner for Type I tanks is a cylinder of 0.5-inch thick carbon steel. The inner radius of the primary liner is 37.5 feet and the inner height is 24.5 feet. The walls of the primary liner are connected to the top and bottom of the waste tank by a 0.5-inch thick, curved knuckle plate. [SRR-CWDA-2010-00128]

Type I tanks have an annular space with a width of 2.5 feet. The base of the annular space is formed between the primary liner and 5-foot high secondary liner pan. The upper annular space is formed between the primary liner and the concrete vault. Carbon steel stiffener angles are located at the top of the secondary liner. [SRR-CWDA-2010-00128]

2.1.2 **Support Columns**

Twelve columns support the roof of a Type I tank. These columns were made from steel pipes welded to a steel bottom plate. The pipes are 0.5-inch thick carbon steel with a 2-foot outside diameter and are filled with reinforced concrete. The columns have flared capitals at the top also filled with concrete. The bottoms of the columns are cylindrical and have eight, 1-inch thick stiffener plates on each column. The columns are welded to the top and bottom of the primary liner (Figure 2.1-2). [SRR-CWDA-2010-00128]

Figure 2.1-2: Support Column Dimension Details



2.1.3 **Cooling Coils**

Cooling coils in Type I waste tanks are configured in both a horizontal and a vertical array, which create obstacles to waste removal and other activities inside the waste tank (Figure 2.1-3). Each Type I waste tank contains 34 vertical cooling coils that are supported from the primary tank roof by hanger and guide rods, which are welded to the primary tank. All combined, the vertical coils consist of 604 vertical sections 18.5-feet long with 604 loops (half circle with a 24-inch radius) that connect the vertical sections. Two horizontal cooling coils (upper and lower) traverse the bottom of the waste tank and are supported by guide rods welded to the primary tank floor. The lower horizontal cooling coil is approximately one inch above the tank floor and the upper horizontal cooling coil is approximately four inches above the primary tank floor. The horizontal coils consist of 26 horizontal sections and 26 loops (half circle with a 24-inch radius) that connect the horizontal sections. In addition, there are supply pipes that connect the tank top cooling water system to the cooling coils. There are approximately 22,800 linear feet of 2-inch carbon steel pipe cooling coils in a Type I waste tank. [SRR-CWDA-2010-00128]

Figure 2.1-3: Tank 12H Cooling Coils

2.1.4 **Waste Tank Concrete Vault**

A concrete vault, 80-foot inner diameter, surrounds the Type I tank primary liner. The space between the vault and the primary liner creates a 2.5-foot wide annulus. The vault is formed by a 22-inch thick reinforced concrete roof and walls that surround the primary container and connect to the basemat. The walls have horizontal construction joints but no vertical construction joints were used. [SRR-CWDA-2010-00128]

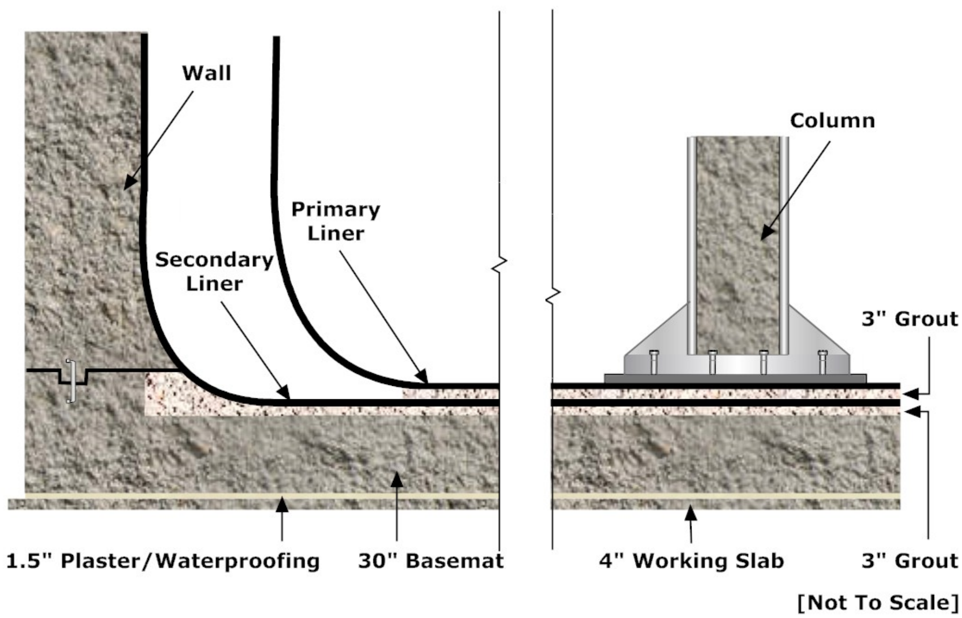
Because of the high water table around the HTF Type I tanks, the concrete vaults included waterproofing. At the bottom of the concrete vault, a 5-ply layer of bituminous impregnated cotton fabric (waterproofing membrane) was placed between the 4-inch thick concrete working slab and the concrete basemat. An additional 5-ply layer of waterproofing membrane was placed above the 5-ply layer from the bottom of the concrete vault up to the basemat/vault wall construction joint. Between these two layers of waterproofing membrane exists a 0.25-inch thick flashing of metal reinforced fabric. A 5-ply layer of waterproofing membrane was placed on the top of the concrete vault and covered with a 0.25-inch layer of cement plaster or fiberboard, which was covered with 2 inches of shotcrete. An additional 3-ply layer of waterproofing membrane was placed below the 5-ply layer from the top of the concrete vault down to the roof/vault wall construction joint. A 0.25-inch thick flashing separates the two layers of waterproofing membrane. A 5-ply layer of waterproofing membrane was also installed on the concrete vault walls and a 4-inch thick brick wall was constructed 4 inches from the waterproofing membrane on the concrete vault wall. The 4-

inch annular space between the brick wall and the waterproofing membrane on the concrete vault wall was filled with bituminous grout (hot sand asphalt mastic). [SRR-CWDA-2010-00128]

2.1.5 Working Slab and Basemat

The working slab for a Type I tank is 4-inches thick, with a radius of 42 feet 5 inches, and has a 2-inch wire mesh layered in the middle. A 1.5-inch thick layer of plaster/waterproofing membrane sits above the working slab. A 30-inch reinforced concrete base (basemat) sits on top of the plaster. A 3-inch layer of construction grout fill sits on top of the basemat and the secondary liner sits above the grout. In addition, a 3-inch thick layer of grout is placed between the base of the primary liner and the secondary liner. Figure 2.1-4 portrays the details of a typical Type I tank floor, basemat and working slab configuration. [SRR-CWDA-2010-00128]

Figure 2.1-4: Typical Type I Floor Configuration



2.1.6 Type I Waste Tank Access and Riser Configuration

Visibility and equipment manipulation access within the Type I waste tank is limited by the design configuration of the waste tank risers and distance from ground surface to the waste tank floor. Riser configuration, above the waste tank top, limits direct access to the interior, and allows only a limited view and access to the waste tank floor as shown in Figures 2.1-5 and 2.1-6. Additionally, the size of the access ports limits the manipulation of long-handled mechanical tools. Due to access port geometry, choices are limited as to the types of remote equipment that can be successfully deployed. Also, the risers may be impeded by installed equipment such as instrumentation (e.g., thermocouples, conductivity probes), abandoned equipment (e.g., pumps, transfer jets), and supplemental ventilation. As originally designed and constructed, the roofs of Type I waste tanks have nine primary and four annulus access risers. Type I waste tanks have a 42-inch diameter center riser and eight 24-inch diameter risers around the perimeter of the tank primary containment. The four annulus risers are located with one in each quadrant of the cylindrical tank. Figure 2.1-6 depicts the relative location of the waste tank access risers. From the top of each riser to the primary tank roof is a depth of approximately 10 feet 10 inches (nine feet of earth cover and 1-foot 10 inches of concrete tank top roof). [SRR-CWDA-2010-00128]

Additional details for the Type I tanks are provided in Section 3.0 of the HTF PA. [SRR-CWDA-2010-00128]

Figure 2.1-5: Type I Waste Tank Access Risers for Waste Removal Equipment Diagram

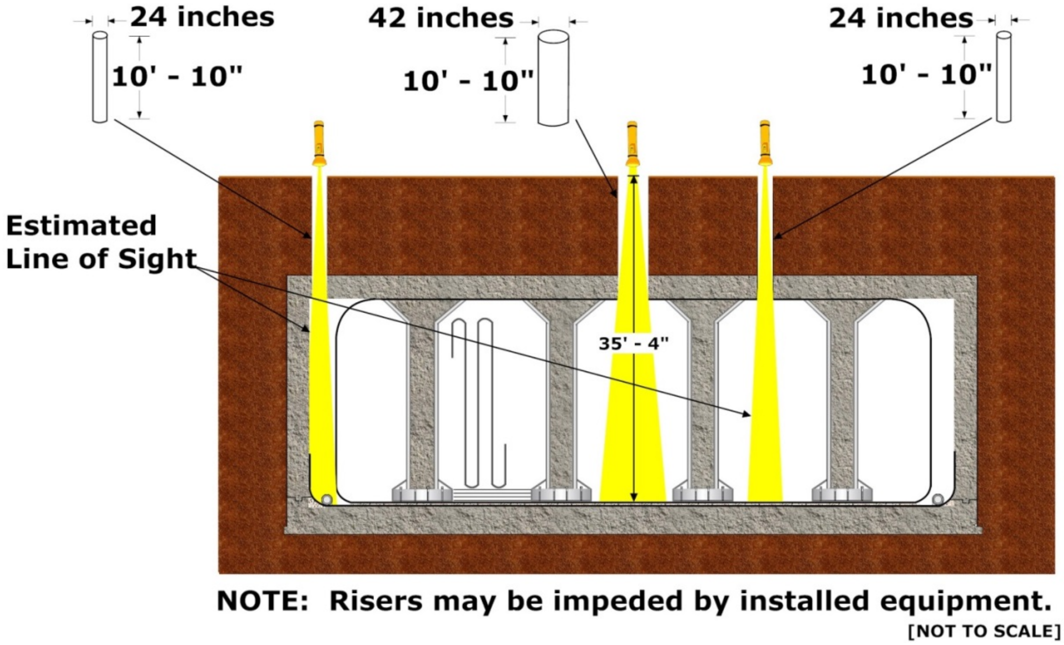
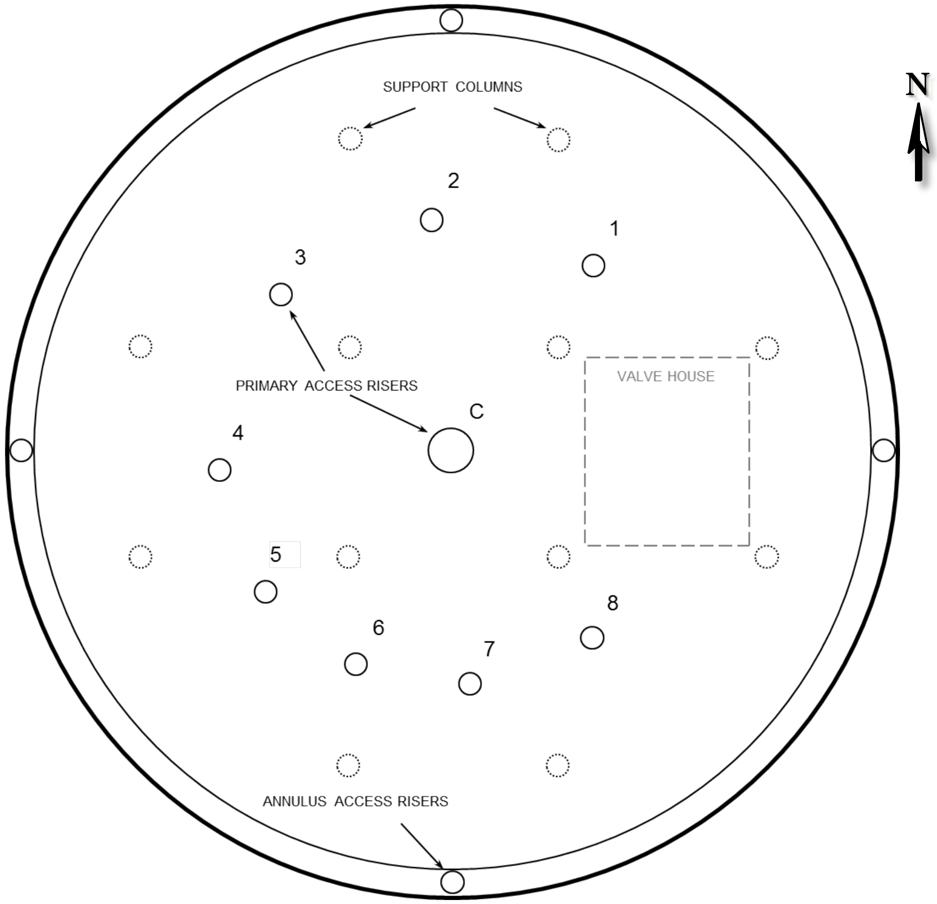


Figure 2.1-6: Tank 12H Primary and Annulus Riser Configuration



2.2 Tank 12H Operational Service History

This section summarizes information on the waste types received and processed through Tank 12H. It is not intended to be a detailed accounting of all waste transfers to and from the tank throughout its operational history. Details on the waste removal operations conducted in Tank 12H are provided in Section 3.0.

2.2.1 Tank Operational Service Summary

In September 1956, Tank 12H was placed in service to receive periodic transfers of fresh high-heat waste (HHW) from H-Canyon operations. When the volume of waste in the tank neared operational capacity, additional receipts were suspended. Insoluble solids were allowed to settle, forming a sludge layer on the bottom of the tank. The waste was then allowed to cool and decay radioactively until aged supernatant liquid met acceptance criteria for transfer to an evaporator system for volume reduction purposes. From August 1963 through December 1974, the process of filling Tank 12H with fresh HHW and decanting the supernate was performed five times. Comprised of settled solids and interstitial liquid, the sludge layer at the bottom of the tank grew larger after each decant. [DPSPU 78-11-9] Tank 12H received HHW from the following three chemical separations processes:

- Plutonium-Uranium Extraction (PUREX), which was associated with recovery of weapons grade plutonium and uranium from natural and depleted uranium targets

- H-Modified (HM), which was associated with recovery of highly enriched uranium from spent uranium fuel and neptunium targets
- Thorium Extraction (THOREX), which was associated with the recovery of U-233 from thorium targets

The HM and THOREX processes yielded waste streams with a high aluminum concentration, which affected the rheological properties of the sludge and later contributed to difficulty during waste removal (described in detail in Section 3.0). Table 2.2-1 shows a summary of the time periods during which Tank 12H received each of the waste streams.

Table 2.2-1: Tank 12H Waste Receipt Summary

Time Period	Process Source for Waste Stream Received
Sep 1956 - Nov 1957	PUREX
Oct 1963 - Mar 1964	HM
April 1964 - May 1964	THOREX
June 1964 - July 1969	HM
Aug 1969 - Oct 1969	THOREX
Feb 1970 - May 1973	HM

In June 1973, the liquid level in Tank 12H reached its highest historical fill level of 269 inches or 729,000 gallons. [DPSPU 78-11-9]

In May 1974, leakage from the primary tank to the annulus was first identified when a small salt-encrusted deposit was observed in the annulus on the outside of the primary tank wall at the 105-inch level. Previous annulus inspections had not identified any leak sites. The leak site, about four feet counterclockwise from the north annulus riser, was inactive at the time of discovery but the decision was made to discontinue use of Tank 12H for fresh waste receipts shortly after the discovery of the leak site. [DPSPU 78-11-9]

Supernate removal was accomplished through a series of three liquid transfers to Tank 13H, beginning with a transfer of 150,000 gallons in March 1976. Another 90,000 gallons was transferred during April 1976 and 106,000 gallons was transferred during August 1978. Over time, the remaining supernate eventually evaporated and the sludge layer desiccated, shrinking from 95 inches to 75 inches, while Tank 12H remained dormant until 2004 when preparations for sludge removal activities were initiated.

Tank 12H has four annulus risers and due to limited line of sight around the curved surface, only 25% of the annulus could be inspected. Five additional leak sites were discovered between 1974 and 2008 during annual inspections through the four annulus risers. [SRR-LWE-2012-00144]

As part of completing sludge removal activities, a 100% inspection of the Tank 12H annulus was performed in 2012 using a magnetically mounted wall crawler. During this inspection, an additional nine leak sites were discovered. The total volume of waste in the annulus from all leak sites was estimated to be less than 30 gallons. An overall location summary for each of the 15 leak sites is shown in Table 2.2-2. [SRR-LWE-2012-00144]

Table 2.2-2: Tank 12H Leak Site Summary

Year Discovered	Location Relative to Tank Orientation	Elevation (inch) Relative to Tank Floor
1974	North	105
1984	North	93
2004	North	95
2005	North	70
2005	South	129
2008	NE	85
2012	NW	129
2012	NW	129
2012	NW	129
2012	SW	129
2012	SW	129
2012	SE	129
2012	SE	129
2012	NW	230
2012	NW	230

In August 2008, Tank 12H contained approximately 203,000 gallons of sludge (75 inches based on sludge soundings) when Bulk Waste Removal Efforts (BWRE) were initiated using standard Long-Shaft Slurry Pumps (SLPs) for Mechanical Sludge Removal (MSR). [SRR-CWDA-2013-00125] BWRE were declared complete in September 2010 after ten MSR campaigns were performed. Two additional MSR campaigns were conducted prior to implementation of the Low Temperature Aluminum Dissolution (LTAD) chemical cleaning technology in June 2011. Between January and June 2012, the sludge heel was washed with low sodium supernate and water during five additional MSR campaigns prior to beginning three bulk oxalic acid (BOA) chemical cleaning campaigns in June 2013. After the final waste removal efforts were completed, Tank 12H was estimated to contain less than 2,000 gallons of residual sludge heel. The details of waste removal operations are described in Section 3.0.

3.0 WASTE REMOVAL

3.1 Tank 12H Waste Removal Overview

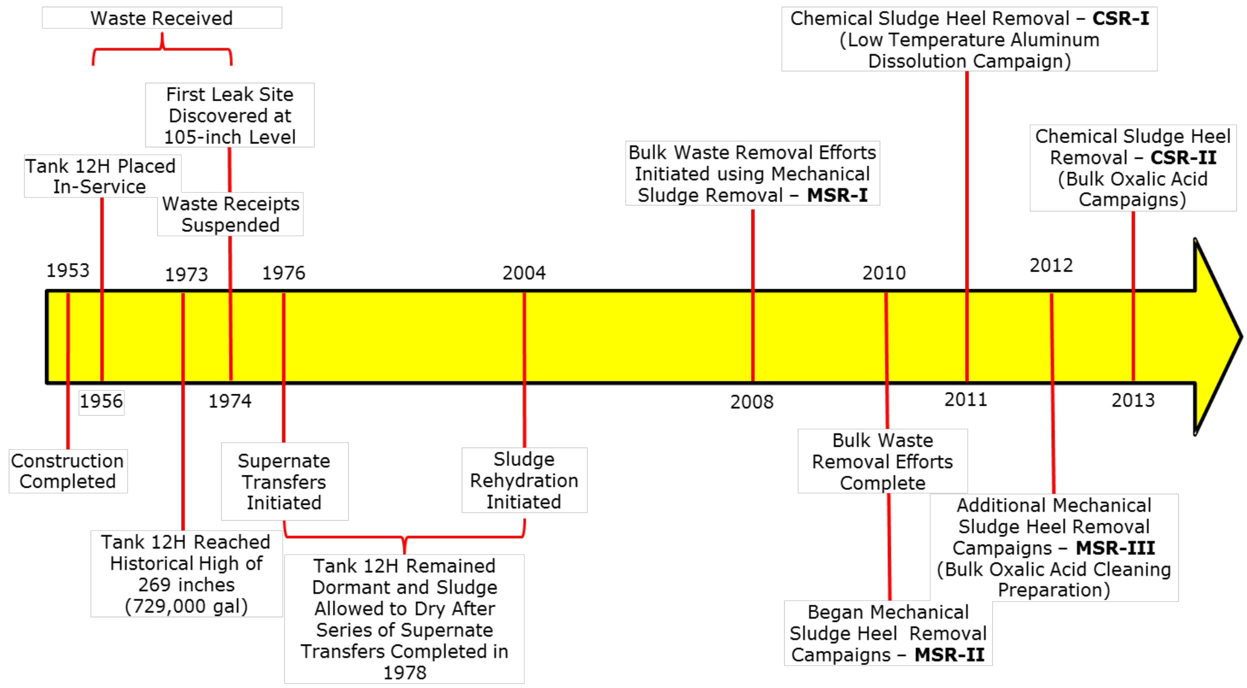
Tank 12H was taken out of operational service in 1974 after minor leakage into the annulus was discovered. Soon thereafter, planning was initiated to remove the bulk of the supernate (i.e., freestanding liquid) waste from the primary tank. The intent was to remove enough liquid that the remainder of waste in Tank 12H would reside safely below the leak site located 105 inches above the tank floor. In March 1976, transfers of supernate from Tank 12H began and a series of three liquid waste transfers were completed by August 1978. Solid waste (i.e., sludge) removal was later achieved through a series of campaigns using technologies categorized as either MSR or chemical sludge removal (CSR). Although both MSR and CSR employ mechanical mixing to suspend settleable solids in liquid slurry, MSR typically uses supernate decants to supply the liquid slurry medium, where CSR involves the addition of chemicals that react with the solids to improve removal efficiency. The specific nature of each cleaning campaign is discussed in detail throughout this section. [U-ESR-H-00062, U-ESR-H-00125, M-CLC-H-03256]

Overall, waste removal in Tank 12H was conducted in three phases:

- Phase 1: Bulk Liquid Waste Removal
- Phase 2: Bulk Solid Waste Removal
  - MSR-I: 10 Campaigns
- Phase 3: Heel Removal
  - MSR-II: 2 Campaigns
  - CSR-I: 1 Campaign
  - MSR-III: 5 Campaigns
  - CSR-II: 3 Campaigns

Figure 3.1-1 shows the Tank 12H historical timeline from construction through completion of waste removal activities. The key waste removal activities on this timeline are described throughout this section.

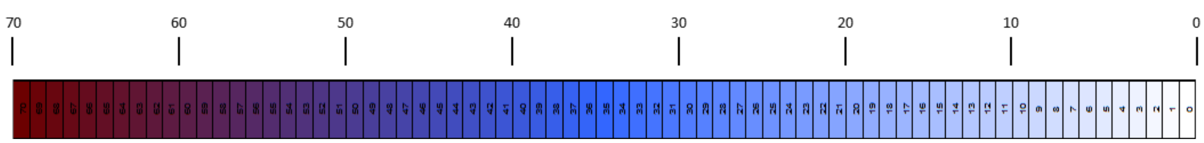
Figure 3.1-1: Tank 12H Historical Timeline



[Not to Scale]

Inspections of the tank interior were conducted after completing each waste removal campaign to assess the remaining solids volume and/or distribution. Most inspections were conducted to support the refinement of the pump operation plan for the next campaign without formal estimation of the remaining volume. However, at certain stages during the waste removal process, video footage and/or still photographs collected during the inspections were used to create topographic maps of the remaining material in the waste tank for volume estimation purposes. When tank mapping was performed, the mapped waste height was plotted on a scale model of the waste tank to produce an estimate of the residual material volume for evaluation of the technology's effectiveness and overall cleaning progress. The residual material mapping process is described in detail in *Tank Mapping Methodology*. [SRR-LWE-2010-00240] Figure 3.1-2 shows the color scale for sludge heights on the topographical maps included in subsequent figures. As described in Section 2.1, each vertical inch in the primary tank is equivalent to 2,710 gallons.

Figure 3.1-2: Color Scale for Topographical Sludge Maps



Height is shown decreasing from left to right, with red being the highest (70 inches) and white the lowest (0 inches)

3.2 Tank 12H Waste Removal Phase 1: Bulk Liquid Waste Removal

Bulk liquid waste removal was accomplished through a series of supernate transfers from Tank 12H to Tank 13H, beginning in March 1976 and ending in August 1978, that reduced the liquid level in Tank 12H below the 105-inch leak site. After the supernate was transferred, a 257,000-

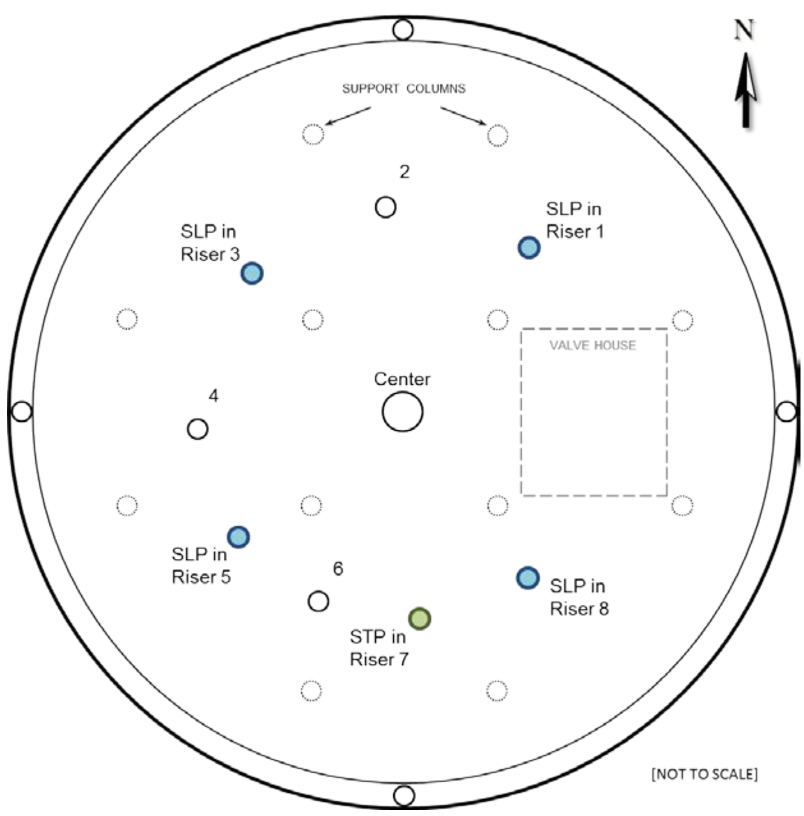
gallon (95-inch) wet sludge layer comprised of settled solids (i.e., insoluble metals) and interstitial liquid was left behind. The remaining sludge layer desiccated over time, shrinking from 95 inches to 75 inches. Tank 12H did not receive any significant additional liquid until 2004 when rewetting of the dried sludge was initiated in preparation for removal activities. [U-ESR-H-00062]

3.3 Tank 12H Waste Removal Phase 2: Bulk Waste Removal Efforts

3.3.1 Technology Selection for Phase 2: Bulk Waste Removal Efforts

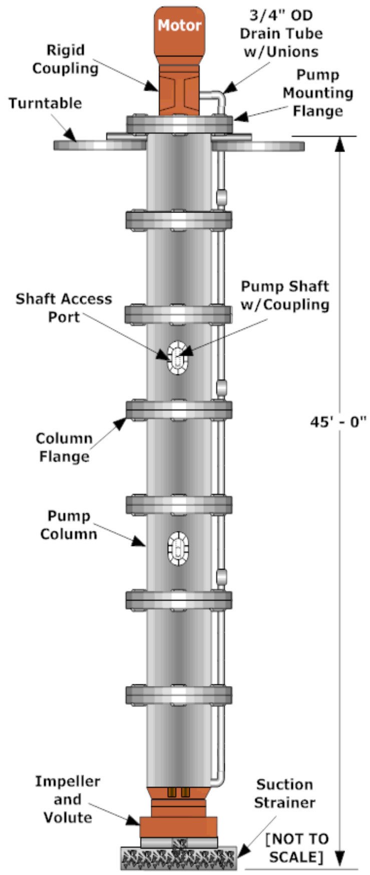
Based on previous experience, equipment availability, and limited availability of storage space in the tank farm, a low-pressure, sludge-slurrying technique was selected as the optimum waste removal technology for Tank 12H BWRE. Using lessons learned during waste removal campaigns in other tanks and studies conducted at the Training and Experimental Test Facility (TNX) full-scale test tank, four Long Shaft SLPs were strategically placed, one in each quadrant of the tank, to maximize the technology's effectiveness. A submersible transfer pump (STP) was located in Riser 7 to transfer slurry from Tank 12H. Initial plans were to use the four SLPs until the technology reached the end of its practical ability, and diminishing effectiveness was observed, at which point additional removal technologies would be evaluated for use in Tank 12H. [U-ESR-H-00062] Figure 3.3-1 shows the location of the STP and four SLPs during Phase 2 and Phase 3 of the waste removal efforts in Tank 12H.

Figure 3.3-1: Tank 12H Equipment Locations during Tank 12H Waste Removal Phase 2 and Phase 3



To operate SLPs, a sufficient amount of liquid needed to be added to the waste tank for the sludge to reach an appropriate consistency to be drawn in through the suction strainer and forced out through the two diametrically opposed volute nozzles. The resulting stream of sludge slurry is capable of dislodging and eroding compacted solids in the flow path. The SLPs were initially operated with the suction (located at bottom of the pump shaft) near the liquid-solids interface and gradually lowered in prescribed increments over a period of time. This technique was necessitated by the dense state of the settled sludge, which initially prevented full insertion of the pumps. [U-ESR-H-00062] A typical SLP design is illustrated in Figure 3.3-2.

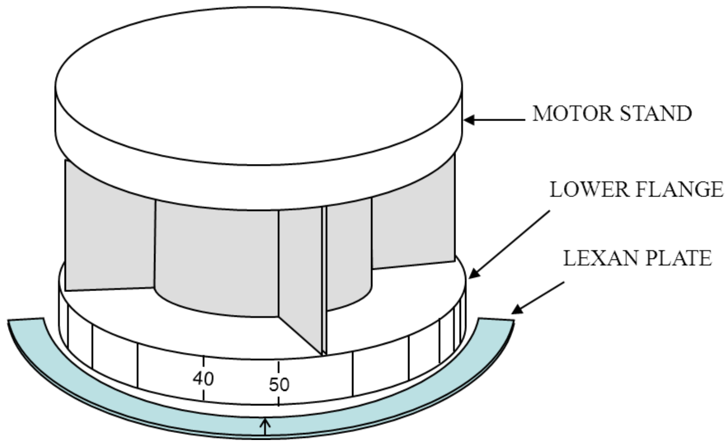
Figure 3.3-2: Typical SLP Design



[DOE-SRS-WD-2014-001]

During mixing operations, the SLPs were operated in two modes, rotational and indexing. In rotational mode, the pumps were continuously rotated 360 degrees using a turntable assembly to create a circular cleaning pattern. The turntable was driven by a 0.5 horsepower reversible motor equipped with a variable speed pulley for adjusting the turntable speed from 0.2 to 0.5 revolutions per minute. For indexing mode, specific locations in the waste tank were targeted by setting the turntable assembly to a fixed position, which also fixed the direction of the pump volutes to allow controlled aiming of the expelled slurry streams. Figure 3.3-3 is an illustration of a SLP turntable.

Figure 3.3-3: SLP Turntable



Note: Pump is indexed to the 48° position
[SRR-LWE-2011-00156]

3.3.2 SLP Operation during MSR-I: Bulk Solid Waste Removal from Tank 12H

The MSR-I campaigns focused on the removal of gross amounts of the solids, and were not expected to preferentially separate any radiological or chemical constituents within the solids.

Preparation for MSR-I

Beginning in November 2004, Inhibited Water (IW) and corrosion control chemicals were added to Tank 12H to rewet the sludge solids. The rewet operation was considered complete in January 2005 after a total of 58,000 gallons of sodium nitrite solution had been added. Due to the dense state of the settled solids, liquid absorption was not immediate and thus free liquid was present atop the solids after the rewet was declared complete. The liquid level after rewet was approximately 80 inches. Due to continued absorption of the liquid into the solids, 32,000 gallons of Tank 51H supernate were decanted and added to Tank 12H in April 2008 to meet safety basis requirements. [S-TSR-G-00001] In May 2008, another 89,000 gallons of supernate were transferred from Tank 51H, increasing the liquid level in Tank 12H to approximately 110 inches in preparation for SLP operation. [U-ESR-H-00062] (Note: the total liquid additions to Tank 12H prior to MSR-I do not add up to equal the tank liquid level because of continued absorption during the sludge-rewet process.)

MSR-I Campaign 1

Prior to initiation of bulk solid waste removal, an estimated 203,250 gallons (75 inches) of solids and approximately 94,850 gallons (35 inches) of supernate were present in Tank 12H for a total volume of 298,100 gallons (110 inches). Each of the four SLPs was initially installed so that the bottom of the suction screen was 69 inches above the tank floor and the STP was suspended in a caisson at 144 inches. (Note: all elevations referenced within the tank interior are measured from the Tank 12H primary liner floor.) [U-CLC-G-00023, U-ESR-H-00062]

In August 2008, the SLPs were initially operated in rotational mode for 67 hours at an elevation of 69 inches before being lowered to 60 inches. The SLPs were then operated for 95 hours in rotational mode and 65 hours in index mode before being lowered 10 more inches. At this point, the liquid level had decreased approximately 5 inches due to additional absorption while the sludge solids were being agitated. The SLPs were operated in indexed mode for 225 hours at the 50-inch elevation before the STP was to be lowered to an elevation of 24 inches for the first transfer of slurry from Tank 12H to Tank 51H that would support the compiling of DWPF Sludge Batch (SB) 6. The STP could only be lowered to 70 inches where it settled into very thick material, so it was raised and secured at 72 inches. Then 1,150 gallons of IW were flushed through the STP, and several more attempts were made to lower the pump but all were unsuccessful. The pump was again secured at 72 inches and the transfer procedure was initiated. The SLPs were operated in rotational mode during the transfer attempt. After only 90 minutes, the STP was temporarily shut down when there was no indication of material being transferred. The STP was then flushed with 1,500 gallons of IW and restarted. The transfer was unsuccessful again. The SLPs had run in rotational mode for an additional 36 hours during the failed transfer evolution. [U-ESR-H-00062, LWO-LWE-2009-00203]

While investigating the cause for the failed transfer, the SLPs were operated in rotational mode for 332 hours at the 50-inch elevation, after which they were lowered to 40 inches. An engineering path forward was issued on December 12, 2008 to remove the legacy hard sludge inside the STP caisson and to troubleshoot the STP's Variable Frequency Drive/ electrical system. On January 8, 2009, the STP was raised to 144 inches, a camera was installed to view the impeller, and the pump was tested to verify correct rotation. Hydro-lancing of the caisson (down to the bottom of the waste tank) was performed on January 9, 2009, and an attempt was made to lower the STP. It was lowered to approximately 61 inches before hitting thick sludge and was again raised to 72 inches. [LWO-LWE-2009-00203]

Approximately 29,000 gallons of rainwater were transferred from H-Area Diversion Box (HDB)-1 to Tank 12H between January 11 and 14, 2009 to provide additional slurry medium. With the STP at 72 inches, a Tank 12H to Tank 51H transfer was initiated on January 17, 2009, but was temporarily shut down when neither waste tank showed a change in level. The STP was raised to 84 inches and restarted but the transfer was again unsuccessful. On January 21, 2009, the pump was raised to 96 inches and a "proof test" was conducted, with no SLPs running, but this transfer attempt also proved unsuccessful. [LWO-LWE-2009-00203]

On January 23, 2009, two samples of the sludge were collected through the Center Riser for a rheological evaluation conducted at Savannah River National Laboratory (SRNL). Results from the study revealed an emergent technical issue, that the sludge had a yield stress 4.5 times greater than expected (45 Pascals vs 10 Pascals). [SRNL-L3100-2009-00036] Based on these results, the operating plan was revised to prescribe a greater volume of additional liquid to suspend the sludge into a slurry mixture. The slurry needed to be approximately 6 wt% insoluble solids versus the 11 wt% originally planned. On March 8, 2009, 96,000 gallons of Tank 24H supernate were transferred to Tank 12H to meet the mixture requirements. On March 9, 2009, the Tank 12H to Tank 51H transfer was initiated with the SLPs operating in rotational mode. The first transfer of 170,000 gallons of Tank 12H sludge slurry was completed on March 11, 2009, with the STP at 96 inches; approximately 10 months after initial mixing operations began. [U-ESR-H-00062, LWO-LWE-2009-00203]

In total, the SLPs ran for 936 hours during MSR-I Campaign 1 before successfully completing the first transfer of slurry from Tank 12H. [U-ESR-H-00062]

MSR-I Campaign 2

After MSR-I Campaign 1, the SLPs were lowered to 30 inches and operated in rotational mode for 34 hours before equipment failures on the SLPs in Risers 3 and 5 forced a shutdown of mixing operations during troubleshooting. All four SLPs were restarted the next day but the Riser 5 SLP continued to shut down intermittently. The problem continually persisted during the remainder of the 10-day mixing campaign. The Riser 5 SLP was only operational for a total of 91 hours of the 249-hour, 10-day mixing campaign. [LWO-LWE-2009-00203]

Slurry samples were collected again for rheological analysis at SRNL and again the yield stress was higher than expected, despite having applied lessons learned from the first study. The measured yield stress of 32 Pa for a slurry of 7 wt% insoluble solids did not fit the curve developed during the previous study. [SRNL-L3100-2009-00084] It was noted that shearing of the insoluble particles during the extensive mixing might have contributed to the increased yield stress. [LWO-LWE-2009-00203]

On April 4, 2009, 70,000 gallons of supernate was transferred from Tank 24H to Tank 12H to support the upcoming slurry transfer from Tank 12H, and the STP was then lowered to 48 inches on April 6, 2009. Three SLPs (in Risers 1, 3, and 8) were operated in rotational mode during the transfer initiated on April 8, 2009, and continued to operate after the STP experienced technical difficulties. The troubleshooting was completed the following day and the transfer was once again initiated but, after only 11 hours, the transfer was halted due to inclement weather (a tornado warning had been issued for the area). The Tank 12H to Tank 51H slurry transfer of 185,700 gallons was completed on April 11, 2009. [LWO-LWE-2009-00203]

MSR-I Campaign 3

After MSR-I Campaign 2, the SLPs were lowered to 20 inches and 23,300 gallons of rainwater from nearby oxalic acid (OA) storage tanks were added to Tank 12H to support the mixing campaign. All four SLPs experienced various technical issues during the third MSR campaign and operated intermittently. All four SLPs were simultaneously operational for only 121 hours of the 172 total hours of mixing while the STP was still at 48 inches. The STP was then lowered to 24 inches, two SLPs were lowered to 10 inches and two were lowered to 12 inches. Approximately 73,400 gallons of Tank 51H supernate was decanted and added to Tank 12H on May 19, 2009, raising the liquid level to 95 inches. All four SLPs were operated in index mode for 349 hours prior to lowering the STP to 12 inches in preparation for a Tank 12H to Tank 51H transfer. All four SLPs were operated in rotational mode for 114 hours prior to and during the slurry transfer completed on June 6, 2009. Approximately 166,800 gallons were transferred out of Tank 12H. [U-ESR-H-00062, LWO-LWE-2009-00203]

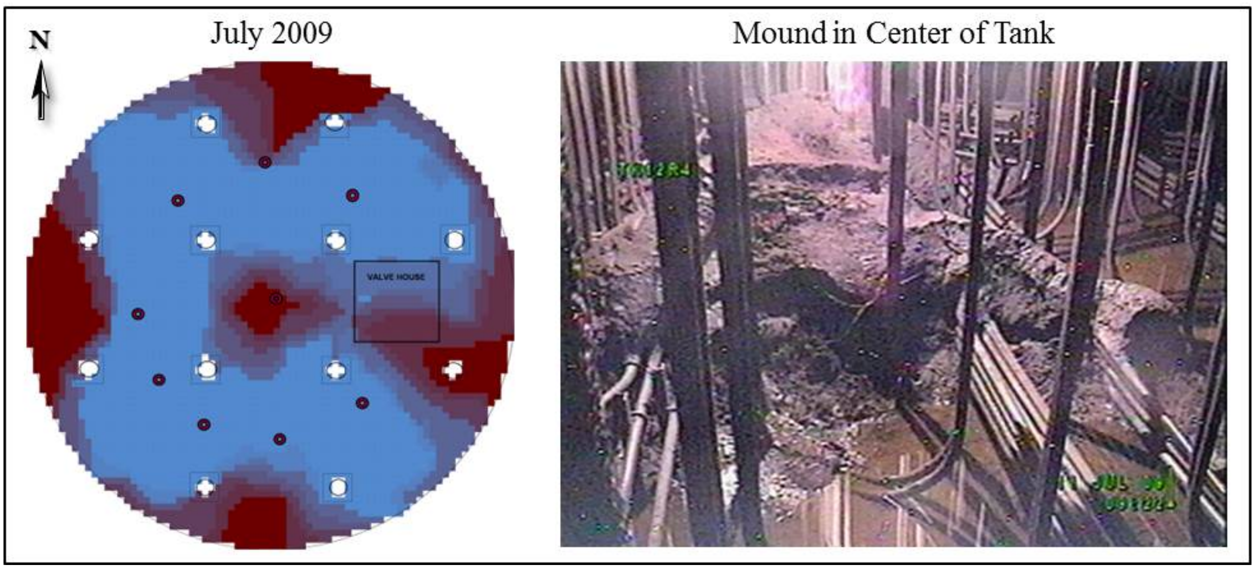
MSR-I Campaign 4

In preparation for MSR-I Campaign 4, 50,000 gallons of supernate from Tank 24H were added to Tank 12H. The SLPs ran for a total of 232 hours during MSR-I Campaign 4, operating in various index sequences before switching to rotational mode just before the slurry transfer of approximately 100,500 gallons to Tank 51H on June 21, 2009. [U-ESR-H-00062, LWO-LWE-2009-00203]

3.3.2.1 Summary of MSR-I Campaigns 1 through 4

The physicochemical properties of Tank 12H sludge that make it more resistant to dispersion were better understood after rheological studies were conducted and an improvement in solids removal was observed after the first two MSR campaigns. When mapping of the residual solids for volume estimate purposes was completed in July 2009, five large mounds were evident, with one in each of the north, south, east, and west quadrants, and one in the center of the waste tank. Figure 3.3-4 shows the mapping results and an image of the center mound after the fourth MSR-I campaign. The four MSR-I campaigns beginning in August 2008 and ending in June 2009 reduced the Tank 12H residual volume from approximately 203,250 gallons to approximately 77,400 gallons, removing 62% of the initial sludge solids from the waste tank. Tank 12H waste removal operations during the first four MSR-I campaigns are summarized in Table 3.1-1. Figure 3.3-5 shows the Tank 12H waste removal history after the first four MSR-I campaigns. [U-ESR-H-00085]

Figure 3.3-4: Effectiveness of MSR-I Campaigns 1 through 4



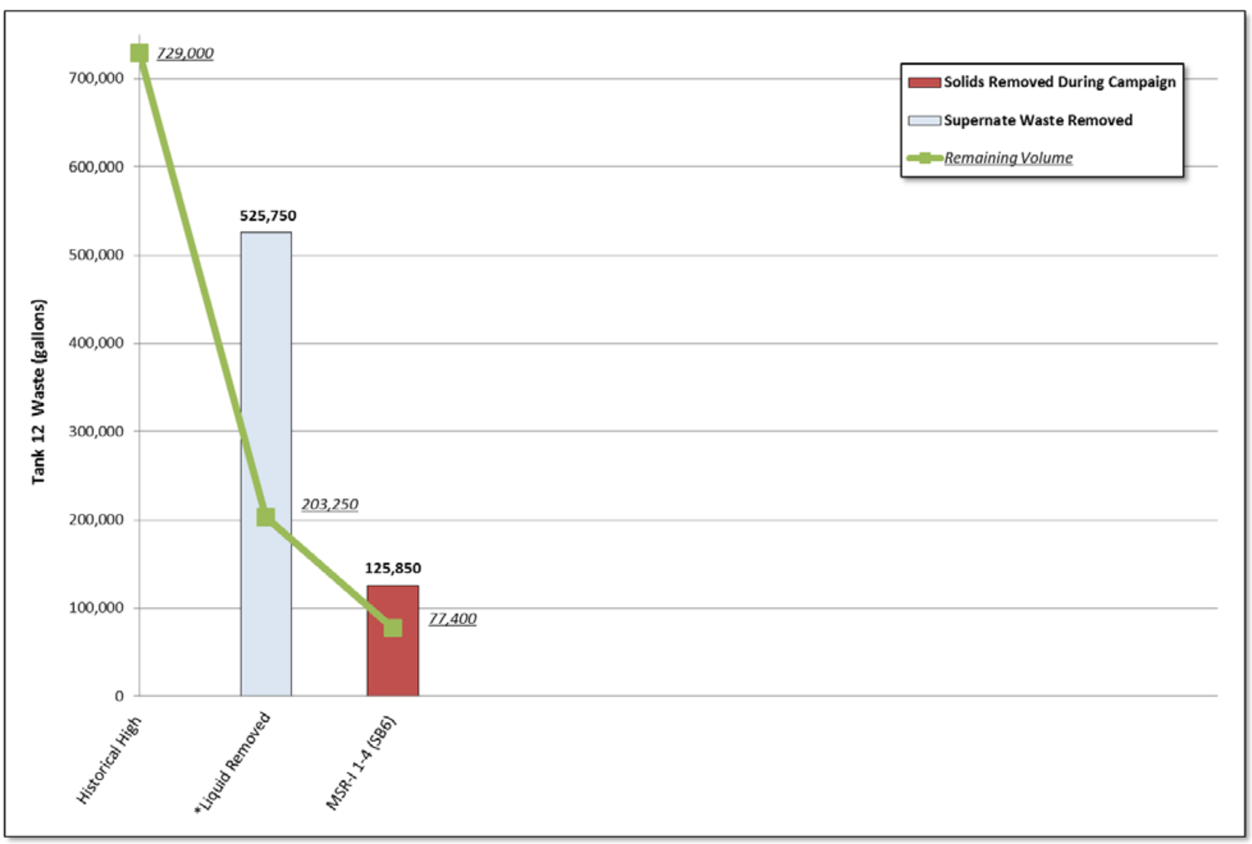
* See Figure 3.1-2 for topographical color scale

Table 3.3-1: Waste Removal Details for MSR-I Campaigns 1 through 4

MSR-I Campaign Number	1	2	3	4
Campaign Duration	8/16/08-3/11/09	3/14/09-4/11/09	4/19/09-6/06/09	6/11/09-6/21/09
SLPs Experiencing Problems	None	Riser 5	All	None
SLP Operating Time (hours)	936	91 w/ 4 SLPs 232 w/ 3 SLPs	584 w/ 4 SLPs 3 w/ 3 SLPs 48 w/ 2 SLPs	232
Supernate Added (gal)	217,000	70,000	73,500	50,000
Other Liquid Added (gal)	89,500	0	23,500	0
Slurry Transferred (gal)	170,000	186,000	167,000	100,500
Solids Remaining (gal)	Unobserved [a]	Unobserved [a]	Unobserved [a]	77,400 [b]
Solids Removed (%)	Unobserved [a]	Unobserved [a]	Unobserved [a]	62
Cumulative Solids Removed (%)	Unobserved [a]	Unobserved [a]	Unobserved [a]	62

Note: Due to inconsistencies in reporting, transfer volumes have been rounded to nearest 500 gallons.
[a] Tank level not low enough to observe remaining solids for volume estimate
[b] This volume may have been over-reported due to uncertainty in the volume estimation
[U-ESR-H-00062, LWO-LWE-2009-00203]

Figure 3.3-5: Summary of Total Waste Volume Removed from Tank 12H at Completion of MSR-I Campaign 4



MSR-I Campaigns 5 through 10

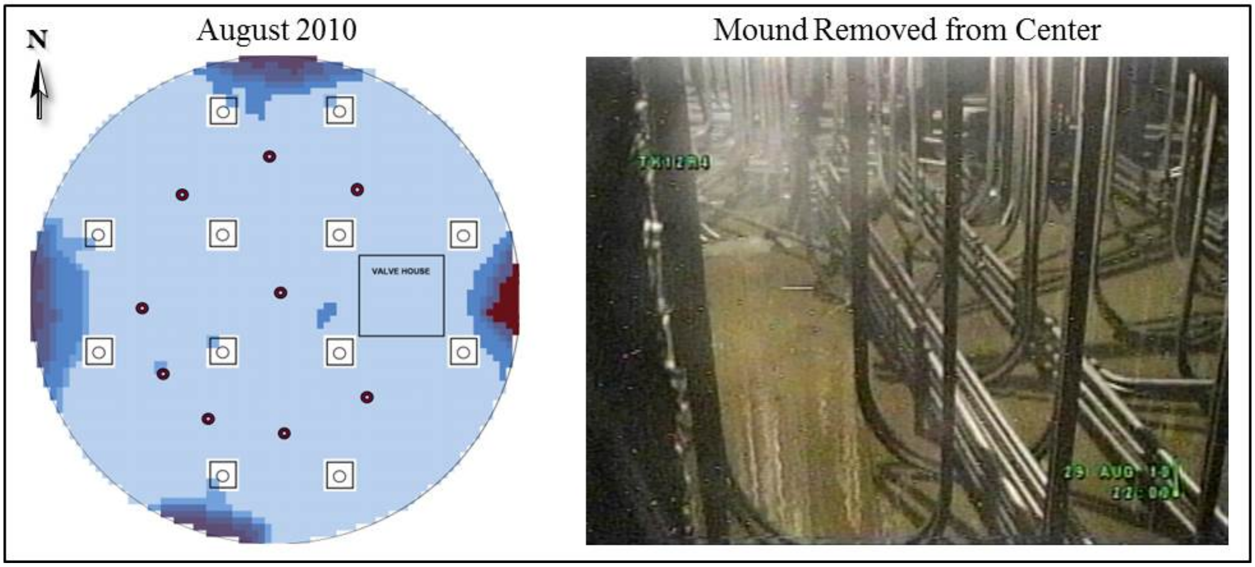
Rheological studies conducted on the Tank 12H sludge during the initial MSR campaign helped considerably to improve the understanding of Tank 12H sludge characteristics. Afterward, the mixing strategy was adjusted to greatly improve the efficiency of MSR. Six additional MSR campaigns were conducted between the end of June and end of August, 2010. Although mixing operations for MSR-I Campaign 5 began in June 2010, the slurry medium (283,000 gallons of Tank 8F supernate) was actually transferred to Tank 12H in July of 2009, to provide space in Tank 8F for the SB6 decant. The SLPs were operated in index mode while focusing on mound reduction and rotational mode during slurry transfers. By following the general strategy established during the first four MSR campaigns, the last six campaigns were successful at reducing mound size and removing the majority of sludge solids remaining. A detailed record of the specific mixing operations was not maintained outside of completed standard operating procedures, and thus the exact duration of the SLP runs is not reported here. However, the waste tank was mapped in August 2010, immediately following the MSR-I Campaign 10, to determine the volume of remaining waste using available photography and videography imaging to create a detailed height estimate of the waste. The heights were plotted over a scale model waste tank to calculate the waste volume.

The center mound had been entirely dispersed and the four other mounds were significantly reduced. The remaining solids volume was estimated to be 22,000 gallons, primarily concentrated in the four mounds. [U-ESR-H-00093]

3.3.2.2 Summary of MSR-I Campaigns 5 through 10

MSR-I Campaigns 5 through 10 reduced the Tank 12H residual volume from approximately 77,400 gallons remaining after Campaign 4 to approximately 22,000 gallons remaining after Campaign 10. MSR-I Campaigns 5 through 10 removed an additional 72% of sludge solids from the waste tank. Figure 3.3-6 shows the mapping results and an image of the waste tank center (previous location of a mound) after MSR-I Campaign 10. Tank 12H waste removal operations during the last six MSR-I campaigns are summarized in Table 3.3-2. Figure 3.3-7 shows the Tank 12H waste removal history after completion of the MSR-I campaigns. [U-ESR-H-00093]

Figure 3.3-6: Effectiveness of MSR-I Campaigns 5 through 10



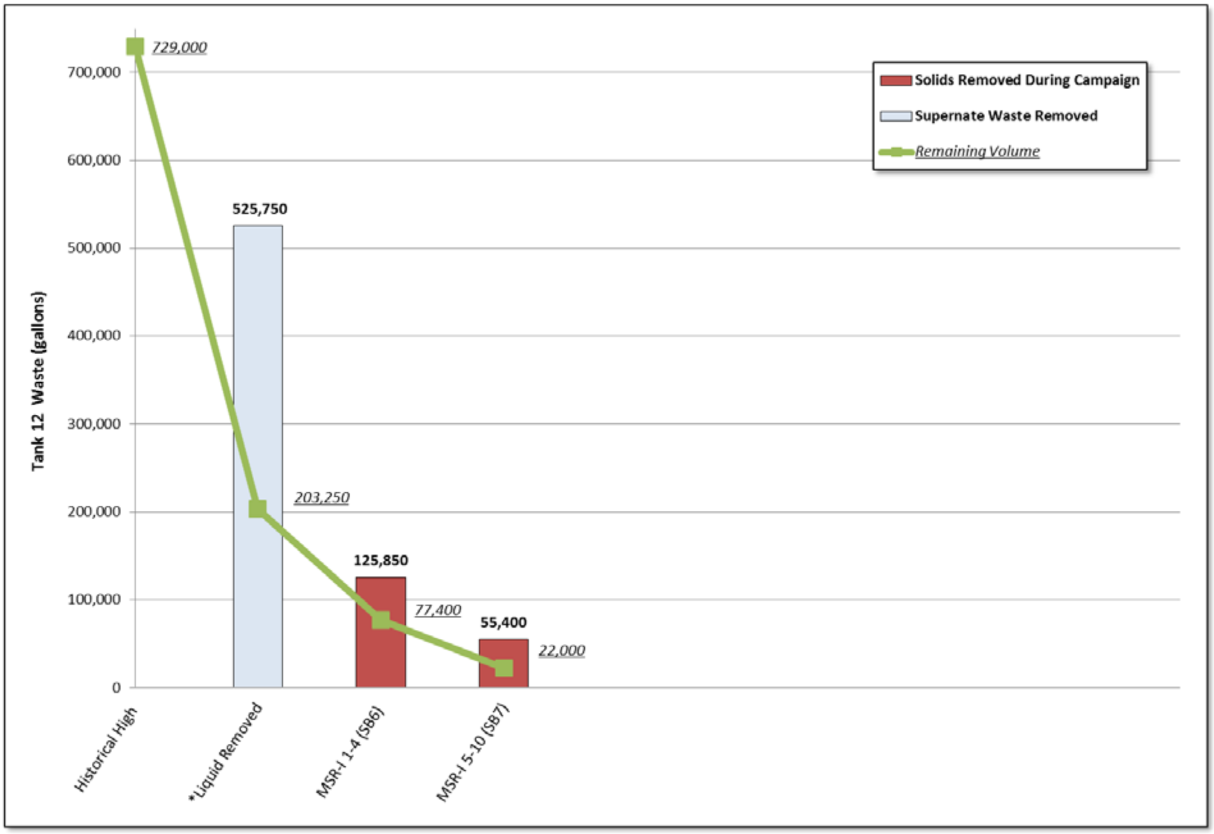
* See Figure 3.1-2 for topographical color scale

Table 3.3-2: Waste Removal Details for MSR-I Campaigns 5 through 10

MSR-I Campaign Number	**5**	**6**	**7**	**8**	**9**	**10**
Campaign Duration	06/25/10-06/27/10	06/29/10-07/25/10	07/31/10-08/02/10	08/04/10-08/05/10	08/13/10-08/15/10	08/15/10-08/27/10
Liquid Added (gal)	283,000	37,500	73,500	149,000	127,500	0
Slurry Transferred (gal)	138,000	42,500	105,000	156,500	137,000	168,500
Sludge Remaining (gal)	Unobserved [a]	Unobserved [a]	Unobserved [a]	Unobserved [a]	Unobserved [a]	22,000 [b]
Solids Removed (%)	Unobserved [a]	Unobserved [a]	Unobserved [a]	Unobserved [a]	Unobserved [a]	72
Cumulative Solids Removed (%)	Unobserved [a]	Unobserved [a]	Unobserved [a]	Unobserved [a]	Unobserved [a]	89

Note: Due to inconsistencies in reporting, transfer volumes have been rounded to nearest 500 gallons.
[a] Tank level not low enough to observe remaining solids for volume estimate
[b] This volume may have been over-reported due to uncertainty in the volume estimation.
[SRR-LWP-2011-00001, U-ESR-H-00093]

Figure 3.3-7: Summary of Total Waste Volume Removed from Tank 12H at Completion of MSR-I Campaign 10



3.3.3 Bulk Waste Removal Efforts Completed

A total of ten mixing and transfer campaigns were required to remove the bulk of solid waste in Tank 12H, which ultimately took more than a year longer than originally projected due to the difficulties in overcoming the unexpected rheological properties of the Tank 12H sludge.

Based on indications that effectiveness was diminishing and additional removal using the SLPs was not expected, a presentation to SCDHEC and and EPA was given on September 8, 2010 and DOE declared BWRE to be complete for Tank 12H. SCDHEC and EPA both provided written concurrence on September 29, 2010. [SRR-CWDA-2013-00125, DHEC_09-29-2010, EPA_09-29-2010]

3.4 Tank 12H Waste Removal Phase 3: Heel Removal Efforts

3.4.1 Opportunity for Continued Heel Removal using SLPs

Process sample data from DWPF SB6 and SB7 indicated an insufficient amount of sludge solids to maintain planned processing rates. At the time, SB6 was being fed to DWPF from Tank 40H and SB7 was undergoing sludge washing in Tank 51H to prepare it for feeding to DWPF. After completion of BWRE in Tank 12H, an extended period of inactivity was expected, while awaiting the availability of submersible mixer pumps (SMPs) from either new procurement or FTF waste tanks. The plan was to replace SLPs in Tank 12H with SMPs, the previously identified technology for heel removal in Tank 12H, in mid-2011.

[SRR-WRC-2011-0004] However, an opportunity to supplement DWPF sludge feed with an additional sludge batch, SB7-B, was realized since it could potentially be prepared using heel material from Tank 12H. Large washing decants from SB7 could be used to initiate early heel removal in Tank 12H and supply supplementary sludge feed to DWPF. This approach utilized the SLPs already in place in Tank 12H. Implementation of this approach would allow the following:

- DWPF planned processing rates to be maintained
- Avoidance of a break in sludge feed material to DWPF
- Avoidance of work to remove SLPs from Tank 12H and insertion of SMPs
- Heel removal activities to start immediately in Tank 12H

3.4.1.1 SLP Operation during MSR-II

MSR-II Campaign 1

In October 2010, approximately 118,000 gallons of supernate was transferred from Tank 42H to Tank 12H to establish mixing conditions. Between October and December 2010, the SLPs were operated in indexed mode specifically to target mounds in each of the four quadrants of Tank 12H. During this campaign, the SLPs in Risers 1 and 3 experienced mechanical problems, and consequently, the northern sludge mound was not appreciably reduced. Approximately 165,000 gallons of sludge slurry was transferred to Tank 7F leaving behind approximately 14,500 gallons of settled sludge. [SRR-LWE-2010-00257, SRR-LWP-2012-00025]

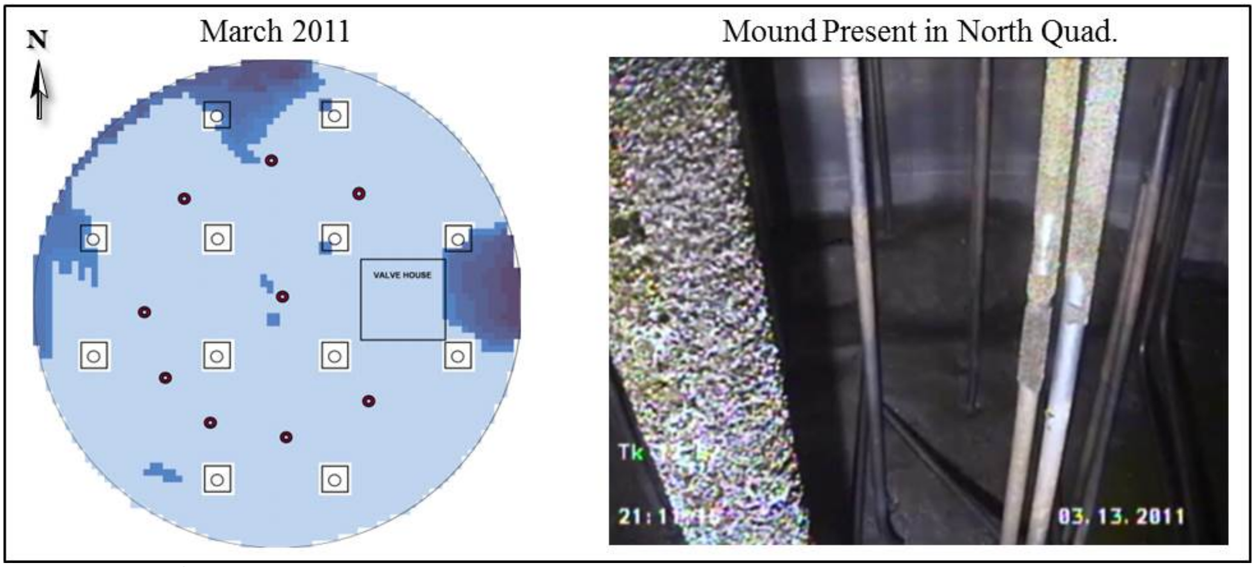
MSR-II Campaign 2

In December 2010, 85,000 gallons of supernate was transferred from Tank 51H to Tank 12H to reestablish the mixing conditions. However, mixing operations did not resume until February 2011 when the SLP in Riser 1 was replaced with a new unit. During this campaign, the SLPs in Risers 3 and 5 experienced mechanical problems and provided minimal effectiveness. Approximately 100,000 gallons of sludge slurry were transferred to Tank 7F on March 9, 2011, leaving approximately 13,700 gallons of settled solids in the waste tank. [SRR-LWE-2011-00099, SRR-LWP-2012-00025]

3.4.1.2 Summary of MSR-II Campaigns 1 and 2

Aside from mechanical difficulties with the SLPs, the MSR-II campaigns performed as expected. Historically, heel removal follows an exponential decay curve (i.e., more effort is required to remove the remaining residue than in the early stages of bulk removal). The two campaigns of mechanical heel removal clearly illustrated this effect. The first campaign removed 34% of the starting volume, while the second campaign removed less than 6%. After nearly six months of operation, mechanical heel removal reached the extent of removal effectiveness for the technology. Therefore, other methods of heel removal had to be used to target the remaining heel. Figure 3.4-1 shows the mapping results and an image of the north mound after the second MSR-II campaign. Tank 12H removal related operations during the MSR-II campaigns are summarized in Table 3.4-1. Figure 3.4-2 shows the Tank 12H waste removal history after the MSR-II campaigns.

Figure 3.4-1: Effectiveness of MSR-II Campaigns 1 and 2



* See Figure 3.1-2 for topographical color scale

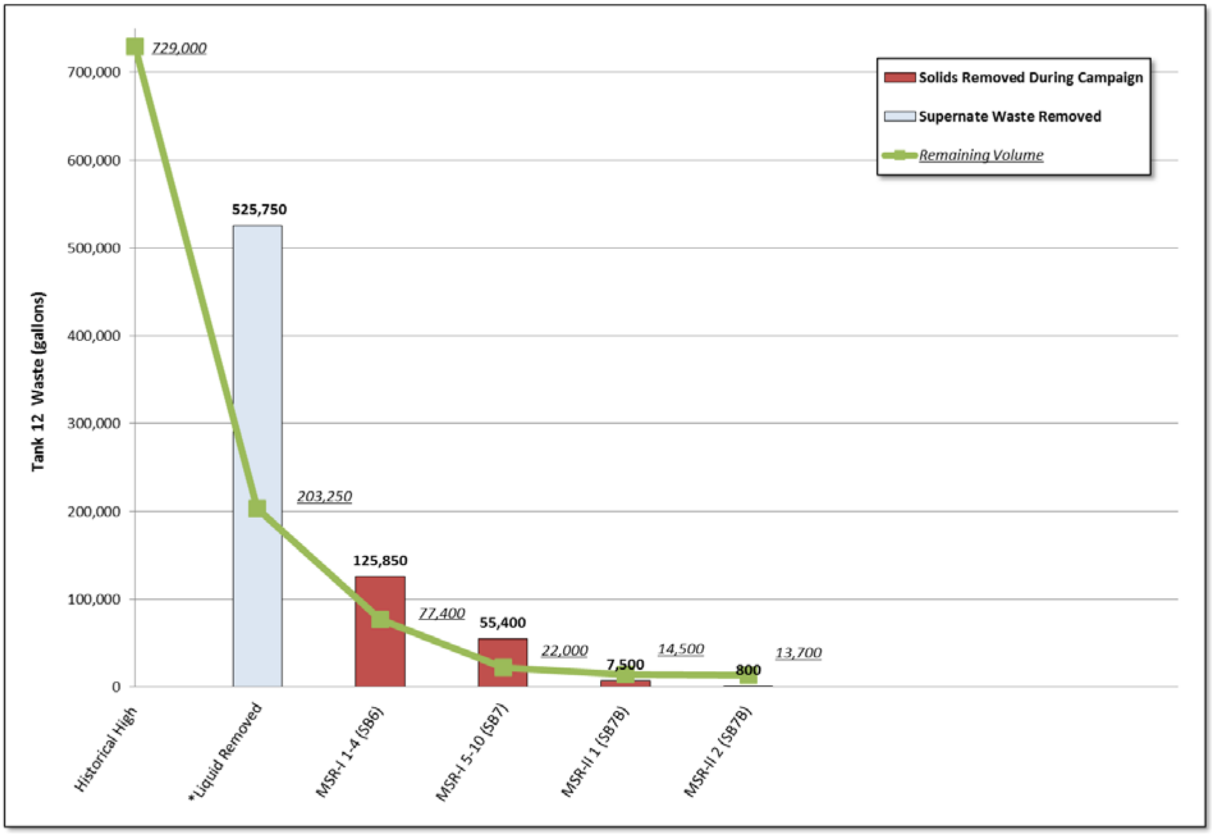
Table 3.4-1: Waste Removal Details for MSR-II Campaigns 1 and 2

MSR-II Campaign Number	**1**	**2**
Campaign Duration	10/09/10- 12/10/10	12/18/10- 03/09/11
SLPs Experiencing Problems	Risers 1 and 3	Risers 3 and 5
SLP Operating Time (hours)	780	492
Supernate Added (gal)	118,000	85,000
Slurry Transferred (gal)	165,000	100,000
Sludge Remaining (gal)	14,500 [a]	13,700 [a]
Solids Removed (%)	34	6
Cumulative Solids Removed (%)	93	93

Note: Due to inconsistencies in reporting, transfer volumes have been rounded to nearest 500 gallons.

[a] This volume may have been over-reported due to uncertainty in the volume estimation.
[SRR-LWE-2010-00257, SRR-LWE-2011-00099, SRR-LWP-2012-00025]

Figure 3.4-2: Summary of Total Waste Volume Removed from Tank 12H at Completion of MSR-II Campaign 2



3.4.2 CSR-I: Heel Removal Efforts Using Low Temperature Aluminum Dissolution

3.4.2.1 Technology Selection for CSR-I

As previously mentioned, the original plan for Tank 12H heel removal was to replace SLPs with SMPs and proceed with a BOA chemical cleaning process for further removal of the remaining heel waste. However, due to the significant wait time for either relocation of SMPs from FTF or procurement of new SMPs from the manufacturer, the project team evaluated other options to expedite heel removal in Tank 12H through continued use of the current SLPs.

In May 2011, a presentation was delivered to SCDHEC and EPA on a revised heel removal strategy. The plan was to use the SLPs in Tank 12H for all additional waste removal efforts, allowing immediate resumption of heel removal efforts. The revised plan also highlighted the introduction of in-tank aluminum dissolution for heel removal purposes. [SRR-WRC-2011-0004]

The sludge heel in Tank 12H was known to have relatively high concentrations of aluminum compounds. Studies and field operations demonstrated that a large portion of these compounds dissolved when continuously contacted with solutions high in free hydroxide. Aluminum dissolution was first identified in the 1980s as part of the original sludge batch washing process as a means of limiting aluminum compounds reaching DWPF for vitrification. As such, aluminum dissolution became a prerequisite to sludge washing. The method involved adding 50 wt% of NaOH (sodium hydroxide) to the processing tank to establish a minimum molar ratio of three moles of free hydroxide to every mole of gibbsite, and a final free hydroxide concentration of 3 molar. The waste tank contents then needed to be agitated for three days while maintaining a temperature within the range of 80°C to 90°C. A drawback of the original aluminum dissolution flowsheet was achieving, maintaining, and operating the waste tank at these high temperatures. Waste tank components would need to be sufficiently robust and extensive technical evaluations would be required before subjecting a specific waste tank to such harsh processing conditions.

The concept of in-situ dissolution in the old style tanks had previously been considered as a prelude to decommissioning, but was later disregarded because of the investment needed to upgrade the tank and its infrastructure (upgrades not considered prudent for tanks facing imminent operational closure).

Beginning in 2006, investigation of aluminum mass reduction using higher caustic solutions was initiated. In lieu of using 3 molar hydroxide solutions at 80°C to 90°C for three days, experiments were conducted using higher hydroxide concentrations at lower temperatures (60°C to 70°C) while extending the exposure time from three days to several weeks. Consideration was given that these processing parameters may result in some reduction in aluminum dissolution effectiveness. However, laboratory studies and experience with lower temperature dissolution in Tank 51H (which contained slurried Tank 12H sludge material) showed that the majority of the aluminum compounds go into solution, and the remaining undissolved sludge exhibits a lower yield stress (i.e., easier to suspend). Therefore, in-situ LTAD was chosen as the second step in the Tank 12H heel removal process. [WSRC-STI-2008-00366]

The flowsheet for LTAD in Tank 12H used information gathered from experience in two LTAD operations performed in Tank 51H. The target temperature was 70°C with a minimum hydroxide concentration of 3.2 molar. A goal of 60% dissolution was projected to require 56 days. The time of operation was estimated to be reduced by 40% to 50% if the temperature remained above 75°C. The resultant aluminum-rich solution would be stored in a Type III/IIIA tank for eventual salt waste treatment and disposal. [SRR-STI-2012-00022]

3.4.2.2 SLP Operation during CSR-I

The LTAD (CSR-I) Campaign was initiated despite the Riser 5 SLP being inoperable, since the other three pumps were located near the remaining mounds, and the Riser 5 SLP would provide minimal contribution to the dissolution effort even if it were operable. The pump operation strategy was to maximize the exposure of the mounds to the heated caustic solution discharged from the SLPs, dissolving the exposed aluminum compounds and uncovering additional solids.

Heated evaporator supernate was used to provide the initial heating of the dissolution medium and supplement the hydroxide concentration to reduce the amount of caustic needed. Following the additions of heated supernate and before the caustic was added to the tank, a baseline sample was taken after the three mixing pumps were operated in a full rotational mode at maximum speed for approximately two hours. The mixing pumps were restarted after sampling and operated for the entire two-day duration of caustic additions. Six tanker trucks of 50 wt% caustic were added for a total volume of 21,000 gallons. [SRR-STI-2012-00022]

The aluminum dissolution process used numerous mixing sequences, with each sequence designed to erode mounds in a particular quadrant of the tank and to mix and suspend as much of the solids as possible. After the completion of caustic additions, the first long term mixing campaign commenced. For a period of nine days, the SLPs operated at maximum speed, alternating between rotational mode and various index sequences. This method of suspending the solids, by operation of the SLPs in rotational mode followed by an aggressive indexing campaign that concentrated on ablating specific mounds, was repeated throughout each mixing campaign. Slurry samples were periodically collected, a total of seven times, to gauge the progress of the LTAD Campaign through observation of the dissolved aluminum concentrations. [SRR-STI-2012-00022]

The SLPs operated for a total of 1,335 hours between June and September 2011 before the collection of the final slurry sample. The slurry temperature remained above 70°C for most of the mixing operation with 87.1°C as the highest recorded temperature. [SRR-STI-2012-00022]

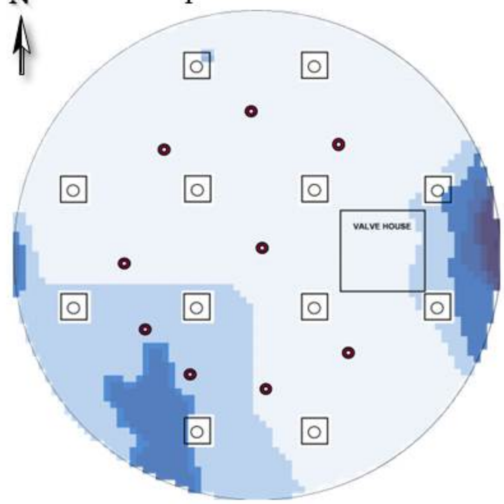
In September 2011, 144,000 gallons of aluminum-rich supernate was transferred from Tank 12H to Tank 21H for eventual incorporation in a salt waste processing batch. The remaining sludge in Tank 12H was formally mapped and estimated to be 7,800 gallons. [SRR-STI-2012-00022, SRR-LWP-2012-00025]

3.4.2.3 Summary of CSR-I

The LTAD process in Tank 12H represents the first time aluminum dissolution was used as a heel removal technique for operational closure of a waste tank. The method dissolved approximately 60% of the aluminum solids. The heel volume was reduced from approximately 13,700 gallons to approximately 7,800 gallons, for a total solids removal of 43%. [SRR-STI-2012-00022]

After LTAD, the cumulative volume of waste had been reduced by 98.9% since the initiation of waste removal efforts. The total solids volume removed was over 96%. Figure 3.4-3 shows the mapping results and an image of the Tank 12H north quadrant (previous location of a mound) after the CSR-I campaign. Tank 12H cleaning related operations during CSR-I are summarized in Table 3.4-2. Figure 3.4-4 shows the Tank 12H waste removal history after CSR-I. [SRR-STI-2012-00022]

Figure 3.4-3: Effectiveness of CSR-I: LTAD



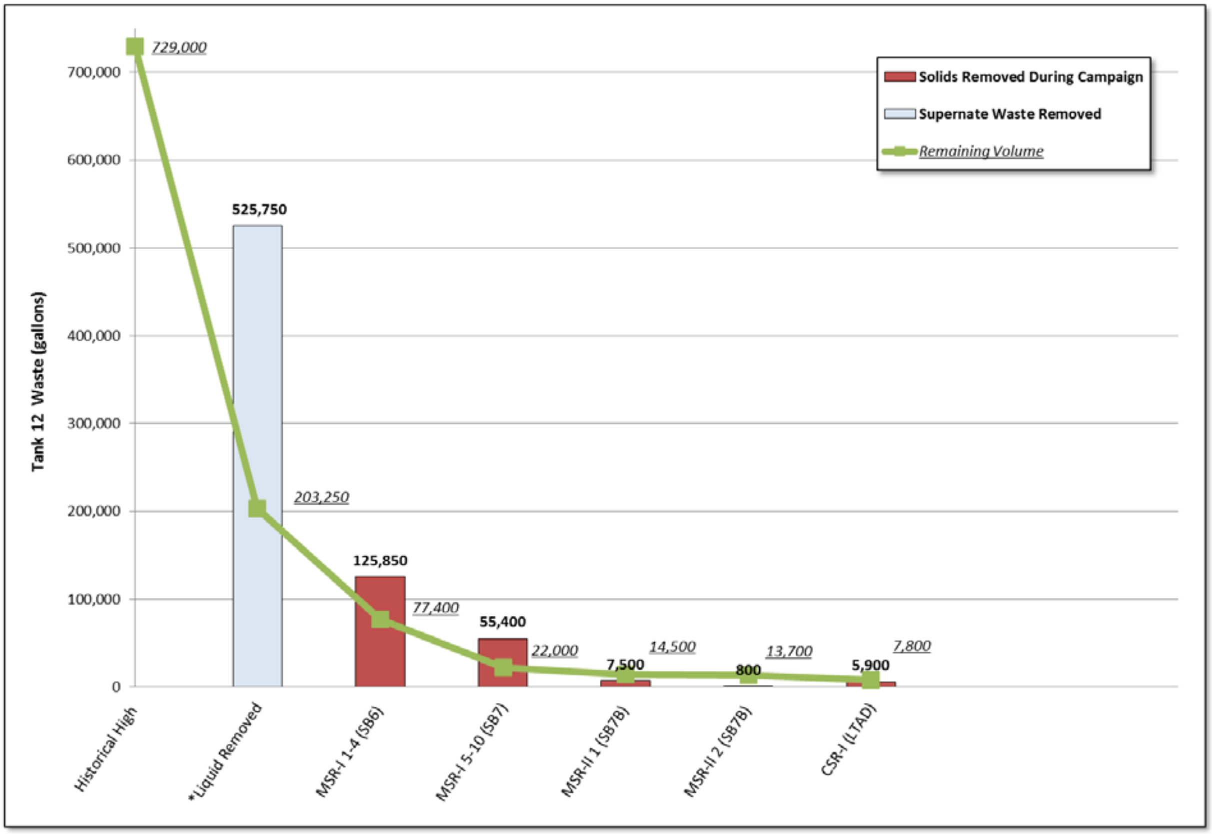
* See Figure 3.1-2 for topographical color scale

Table 3.4-2: Waste Removal Details for CSR-I: LTAD

LTAD Mixing Sequence	A	B	C	D	E	F	G
Sequence Duration	06/23/11-07/04/11	07/06/11-07/13/11	07/14/11-07/23/11	07/25/11-08/03/11	08/03/11-08/16/11	08/16/11-08/29/11	08/31/11-09/16/11
SLPs Experiencing Problems	Riser 5	Riser 5	Riser 5	Riser 5	Riser 5	Riser 5	Riser 5
SLP Operating Time (hours)	276	222	239	247	139	167	44.5
Supernate Added (gal)	109,000	0	0	0	0	0	0
Bulk Caustic Added (gal)	21,000	0	0	0	0	0	0
Slurry Transferred (gal)	0	0	0	0	0	0	144,000
Sludge Remaining (gal)	13,700	13,700	13,700	13,700	13,700	13,700	7,800 [a]
Solids Removed (%)	0	0	0	0	0	0	43
Cumulative Solids Removed (%)	93	93	93	93	93	93	96

Note: Due to inconsistencies in reporting, transfer volumes have been rounded to nearest 500 gallons.
[a] This volume may have been over-reported due to uncertainty in the volume estimation.
[SRR-LWP-2012-00025, SRR-STI-2012-00022]

Figure 3.4-4: Summary of Total Waste Volume Removed from Tank 12H at Completion of CSR-I: LTAD



3.4.3 MSR-III: Heel Removal Efforts Using SLPs during Washing

3.4.3.1 Technology Selection for MSR-III

The MSR-III campaigns employed several lessons learned from the BOA cleaning (BOAC) operations performed on Tanks 5F and 6F. In preparation for BOAC, the heel needed to be washed with low-sodium, clarified liquid to remove as much free hydroxide as possible. Hydroxide needed to be removed since it would act as a buffer, thereby reducing the effectiveness of the upcoming acid strikes. An additional function of these washes was to maximize solids removal through mechanical agitation of the tank contents using the available SLPs. The technique would thereby minimize the volume of acid required during BOAC.

This decision was based on the following observations and conditions:

- Probable changes in sludge rheology caused by LTAD (it was suspected the mounds could be mobilized more readily than when mechanical heel removal was halted)
- Additional sludge retrieved from the waste tank would reduce the volume of OA needed in the final removal step
- Additional sludge would be provided to DWPF SB8

The goals for MSR-III were:

- Reduce the sodium concentration from 8 molar to 0.5 molar, thus minimizing the precipitation of oxalates during BOAC
- Remove some of the remaining sludge deposits, specifically by reducing the mound on east side of Tank 12H (behind the valve house), and reducing the mound in the Riser 5 area of the waste tank

3.4.3.2 SLP Operation during MSR-III

MSR-III Campaign 1

The first wash started in January 2012 when approximately 128,000 gallons of low-sodium wash water from Tank 42H (originally used in Tank 51H for DWPF SB7A and SB7B) was added to Tank 12H. The SLP in Riser 5 was replaced with a new unit prior to the initiation of the campaign but was not operational for the first 140 hours of mixing. After twelve days (265 hours of mix time) of indexed mixing sequences with the SLPs, 119,000 gallons of slurry from Tank 12H was transferred to Tank 51H. [SRR-LWP-2013-00001, SRR-LWE-2014-00154]

MSR-III Campaign 2

The second wash used 131,000 gallons of low-sodium supernate from Tank 51H in February 2012. The SLPs operated for a total of 286 hours before 140,000 gallons of slurry from Tank 12H was transferred to Tank 51H. The waste tank interior was inspected to assess the remaining solids distribution and determine SLP direction for subsequent indexing sequences. [SRR-LWP-2013-00001]

MSR-III Campaign 3

The third wash used 72,000 gallons of low-sodium wash water from Tank 42H in March 2012. The SLPs operated for a total of 186 hours before the slurry from Tank 12H was transferred to Tank 51H. The waste tank interior was inspected to assess the remaining solids distribution and determine SLP direction for subsequent indexing sequences. [SRR-LWP-2013-00001]

MSR-III Campaign 4

The fourth wash used 84,000 gallons of well water in April 2012. The SLPs were indexed for 236 hours specifically to target the east and west mounds. The slurry was then transferred to Tank 51H, after which, Tank 12H was dewatered (pumped down to its lowest possible depth) to adjacent Tank 11H and sludge mapping was performed. [SRR-LWP-2013-00001, SRR-LWP-2012-00037]

MSR-III Campaign 5

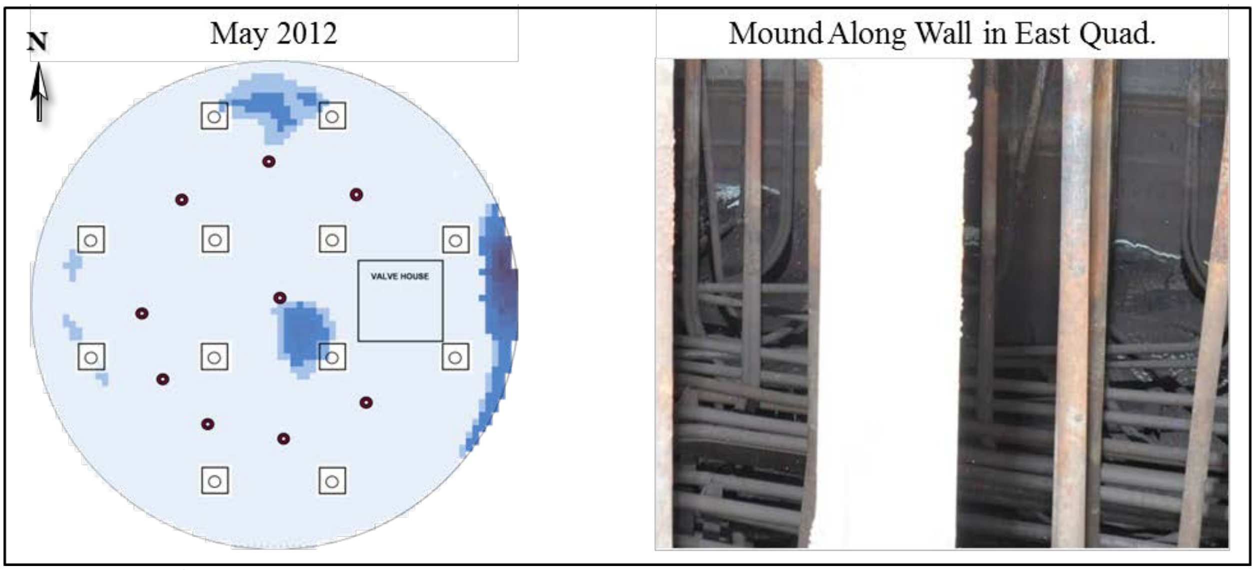
The fifth and final wash began in May 2012 by adding 72,000 gallons of inhibited water comprised of well water, rainwater from HDB-1, and corrosion inhibitors. The pumps ran for 164 hours before the supernate was transferred to Tank 51H. The waste tank was again dewatered and a tank inspection was performed, confirming little or no change in sludge distribution and volume. Therefore, a formal tank mapping was not conducted. [SRR-LWP-2013-00001]

3.4.3.3 Summary of MSR-III Campaigns 1 through 5

In preparation for BOA additions, five washing campaigns were performed between January and May 2012 to remove residual caustic in the sludge, thus optimizing the upcoming CSR campaigns. The first goal of this operation was met by reducing the sodium molarity to 0.48 molar (less than 0.5 molar). The second goal was met by removing residual solids and providing additional sludge mass to DWPF SB8. Inspections after the end of the fourth and fifth campaigns also confirmed that minimal progress was being made, similar to the diminishing effectiveness of the SLPs during mechanical heel removal. [SRR-CWDA-2013-00125, SRR-LWP-2012-00037]

As a result of washing, the heel in Tank 12H was reduced from approximately 7,800 gallons to approximately 4,400 gallons, a 44% reduction. The total solids volume removed was over 97.8% and the cumulative volume of waste had been reduced by 99.4%. Figure 3.4-5 shows the mapping results and an image of the mound in the east quadrant of Tank 12H after the MSR-III campaigns. Tank 12H removal related operations during MSR-III are presented in Table 3.4-3. Figure 3.4-6 shows the Tank 12H waste removal history after the MSR-III campaigns. [SRR-LWP-2012-00037]

Figure 3.4-5: Effectiveness of MSR-III Campaigns 1 through 5



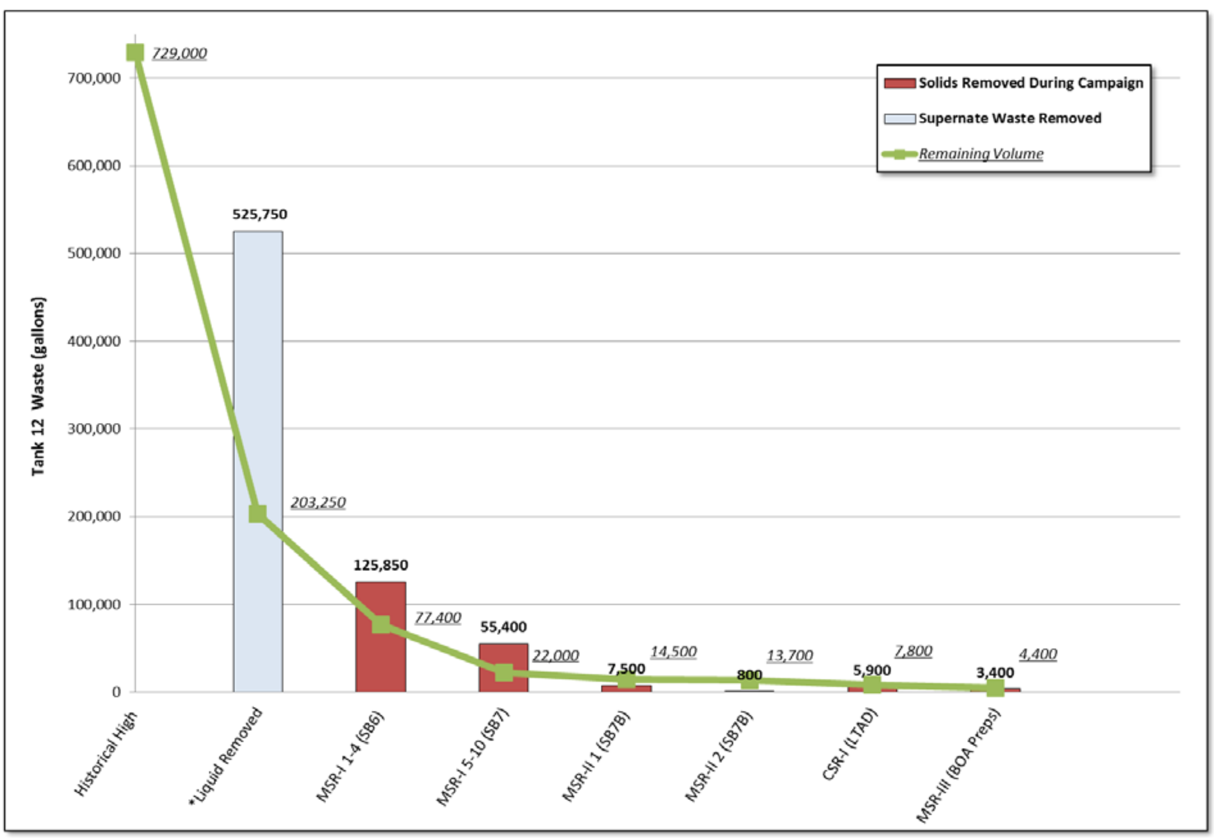
* See Figure 3.1-2 for topographical color scale

Table 3.4-3: Waste Removal Details for MSR-III Campaigns 1 through 5

MSR-III Campaign	1	2	3	4	5
Dates of Run	01/17/12-01/28/12	02/04/12-02/15/12	03/26/12-04/02/12	04/05/12-04/15/12	05/21/12-06/08/12
SLPs Experiencing Problems	Risers 5 and 8	None	None	None	None
SLP Operating Time (hours)	52 w/ 4 SLPs 126 w/ 3 SLPs 140 w/ 2 SLPs	286	186	236	164
Supernate Added (gal)	128,000	131,000	72,000	0	0
Other Water Added (gal)	0	0	0	84,000	72,000
Slurry Transferred (gal)	119,500	140,000	83,000	85,000	64,688
Sludge Remaining (gal)	Unobserved [a]	Unobserved [a]	Unobserved [a]	4,400 [b]	4,400 [b]
Solids Removed, %	Unobserved [a]	Unobserved [a]	Unobserved [a]	44	0
Cumulative Solids Removed, %	Unobserved [a]	Unobserved [a]	Unobserved [a]	98	98

Note: Due to inconsistencies in reporting, transfer volumes have been rounded to nearest 500 gallons.
[a] Tank level not low enough to observe remaining solids for volume estimate
[b] This volume may have been over-reported due to uncertainty in the volume estimation
[SRR-LWP-2012-00037, SRR-LWP-2013-00001, SRR-LWE-2014-00154]

Figure 3.4-6: Summary of Total Waste Volume Removed from Tank 12H at Completion of MSR-III Campaign 5



3.4.4 **CSR-II: Heel Removal Using Bulk Oxalic Acid**

3.4.4.1 Technology Selection for CSR-II

OA has been used as a chemical cleaning agent since the first waste removal demonstration in the early 1980s in Tank 16H and in Tank 24H. Since then, OA was used in bulk, starting in 2008 in Tanks 5F and 6F in preparation for operational closure of those waste tanks.

Lessons learned from the previous BOAC campaigns resulted in the following recommendations for future waste tanks:

- The residual heel should be washed with well water prior to starting OA chemical cleaning to reduce the liquid ionic strength in the heel and reduce any buffering effect
- Ensure the pH of the solution does not exceed 2 to prevent oxalate precipitation
- Mixing helps to promote contact between the acid and residual solids to improve the dissolution rate and also suspends insoluble particles
- Mix the waste tank as soon as a liquid level sufficient to support full speed mixing is reached
- If possible, continue mixing while transferring waste out of the tank until the minimum mixing level is reached
- Heat the OA and maintain the waste tank temperature around 70°C to promote more effective dissolution and minimize precipitation of oxalates

3.4.4.2 Identification and Resolution of Unanticipated Nuclear Safety Concern

During completion of the MSR-III campaign and prior to initiation of BOAC (CSR-II) in Tank 12H, an unanticipated nuclear safety concern emerged. Extensive corrosion testing had been conducted using F-Area sludge waste and simulated sludge material. To prepare H-Area waste tanks for closure, corrosion results for HM sludge, which is a typical H-Area sludge present in Tank 12H, were compared to the previous results for both F-Area sludge and simulated sludge material. As a result of this research and development work, potential accelerated tank corrosion (i.e., pitting) issues associated with HM sludge material were recognized. This new information resulted in new safety concerns outside the existing safety basis documents for H-Area waste tanks. In January 2012, this emergent risk was identified. In February 2012, this risk was confirmed.

The wall and floor of the waste tank could corrode faster than previously expected and assumed, thus jeopardizing the structural integrity of the wall and floor during BOAC. In addition, hydrogen generated by the accelerated corrosion (due to a chemical reaction) raised a potential flammability concern.

Testing was initiated to: (1) determine whether results from previous testing and experiments were applicable and (2) further analyze and quantify the rate of corrosion. Laboratory testing to evaluate the corrosion issue was completed using 2.5 wt%, 4 wt%, and 8 wt% OA at temperatures ranging from 60°C to 75°C. In addition to performing tank wall corrosion testing, impacts to the overall liquid waste system requirements had to be analyzed. Corrosion testing was completed in April 2012 and the results were evaluated. A revised BOAC strategy was selected and a revision to the Tank 12H project schedule was initiated to incorporate the results.

Using the results of the corrosion testing, engineering reports and calculations were developed to support preparation of an HM sludge specific flowsheet for BOAC in Tank 12H. Engineering report *Applicability of SRNL Corrosion Data to Chemical Cleaning in the Tank Farms* (SRR-LWE-2012-00108) discussed the relevance of the corrosion testing to use of BOAC in the tank farms and provided operational recommendations based on the laboratory data. The report included recommendations not only for Tank 12H, but also for all Type I and Type II tanks that contained PUREX and HM sludge wastes. A scope of work and strategy document was prepared to describe the generic BOA chemical cleaning baseline flowsheet for F-Area and H-Area Type I and Type II tanks. [U-SOW-H-00010] Specifically for Tank 12H, a calculation described a flowsheet for transfers into and out of the waste tank and provided the detail regarding how acidic chemical cleaning would be carried out in the associated BOA operating plan. Three acid strikes were planned, each consisting of 8 wt% oxalic acid diluted with water to a 4 wt% solution. Four SLPs were to be used to mix/agitate the diluted acid with the remaining waste heel. The BOA operating plan estimated 12 days to complete each strike as follows: two to three days to add the 8 wt% acid, one to five days to mix and dilute the acidic solution to 4 wt%, two to six days of mixing the dilute solution and the sludge heel, followed by two to three days to transfer the mixed solution out of the waste tank. [X-CLC-H-00896]

To implement the changes associated with the new acid cleaning flowsheet, revised Documented Safety Analysis (DSA) controls were developed as part of a consolidated hazards analysis (CHA) to address the corrosion issue. A review of the safety basis concluded the changes to the hazard and accident analyses were required and that the additional controls were needed to protect the workers, public, and environment.

Initially, Tank 12H was expected to complete acidic cleaning during fiscal year 2012. However, as more information associated with the corrosion issue emerged, unplanned work required for acid cleaning dominated the schedule. The additional work included laboratory corrosion testing, evaluation of results, analysis of overall liquid waste system impacts, hazards analysis, safety basis changes, field modifications to waste tank ventilation instrumentation, technical evaluations, procedure revisions, and employee training. Examples of this effort included, but were not limited to:

- Development of testing plans
- Completion of risk analysis
- Development of a revised flowsheet
- Preparation of engineering calculations
- Implementation of the new Authorization Basis for Acidic Chemical Cleaning
- Establishment of new operating modes in the Technical Safety Requirements
- New Surveillances and Limiting Conditions of Operations
- Revision of more than 25 procedures
- Retraining approximately 200 employees
- Implementation of design changes and modifications associated with material incompatibility

Upon completion of these activities and prior to the addition of OA into Tank 12H, a Facility Self-Assessment and a Level 2 Readiness Assessment were completed to determine that acidic cleaning of the waste tank could be executed safely. Resolution of the emergent technical issue related to BOA increased corrosion resulted in a 12-month impact to Tank 12H closure activities.

In summary, preparing the tank for BOAC required several changes to equipment and baseline safety documents. Those changes included:

- Ventilation upgrades to both the primary and annulus ventilation system (i.e., new acid-resistant purge exhaust fan, new acid-resistant annulus exhaust fan)
- At least one SLP must be operational during acid addition for dilution purposes
- The credited transfer pump cannot be allowed to lower the waste tank level below 12 inches
- Adding a dewatering pump system in the Center Riser (above ground hose-in-hose transfer line, dewatering pump)
- Caustic/acid addition manifold (for safe chemical additions)
- Repositioning the high liquid level conductivity probe to 61 inches

Although OA is considered safe for use in carbon steels, some degree of corrosion attack does occur. Therefore, the following pre-operational requirements and controls were instituted per the *Tank 12 Bulk Oxalic Acid Cleaning Operating Plan* (U-ESR-H-00103):

- Frequent visual annulus inspections,
- Maintain low fill limits in the waste tank,
- Set the annulus leak detection probes to a lower height for earlier warning detection,
- Minimum purge exhaust rates set to 110 standard cubic feet per minute,
- Maintain supernate temperature to less than 60°C before acid addition, and then less than 70°C during dissolution operations,
- Acid concentration kept to 4 wt% or lower,
- Limit the number of OA tanker trucks in the facility to no more than three,
- Chemical addition downcomer must not be allowed to terminate in the liquid,
- Corrosion control sampling is suspended during mixing operations,
- The receipt tank (Tank 51H) downcomer must be kept under the liquid surface to prevent unnecessary splashing of the low pH solution,
- During transfers from Tank 12H, the Tank 51H slurry pumps must be mixing to disperse heat and neutralize the acid,
- Corrosion inhibitors added to Tank 51H to handle all of the material from Tank 12H,
- Tank 51H ventilation must be in operation, and
- Tank 51H must not be in gas release mode during the transfer.

3.4.4.3 SLP Operation during CSR-II

CSR-II Campaign 1

The first BOA campaign was intended to promote general dissolution of loose or easily disturbed residual solids material on the tank floor. Beginning on June 5, 2013, approximately 64,500 gallons of 8 wt% BOA was added to Tank 12H at a 15:1 acid to solids ratio. The acid was diluted with approximately 68,000 gallons of well water. The campaign was put on hold shortly after the addition was completed. During acid dilution, rainwater intrusion into sumps along the transfer path prohibited any transfer from Tank 12H to Tank 51H and forced suspension of the BOA campaigns until the transfer path could be restored.

However, the SLPs were initially operated for one hour to ensure the OA was mixed with the well water long enough to be diluted to 4 wt%. The pumps were then shut down and did not resume operation until June 13, 2013 when the diversion box sumps were cleared for transfer operations. The four SLPs operated at maximum speed for most of the campaign, with the exception of the Riser 5 SLP, which was shut down ten hours after start up because of an electrical drive malfunction. [U-ESR-H-00103]

To observe the reaction rate and thus gauge campaign progress, samples were analyzed for pH during each shift since pH level was the determining factor for initiating the slurry transfer out of Tank 12H. However, inconsistencies in the results of field pH measurements prompted a change to the operating plan on June 18, 2013. The operating plan was revised to require dip samples to be collected and all pH measurements conducted by F/H Area Labs instead of the potentially inaccurate field measurement method. [SRR-LWP-2013-00042, Rev 0] The operating plan revision also included instruction to initiate the transfer after seven days of mixing if the pH did not rise above 1.7, as the reaction would be considered complete based on previous test results. [U-ESR-H-00103]

The slurry transfer of approximately 115,000 gallons to Tank 51H was initiated and completed on June 21, 2013 after the pH did not exceed 1.7. The Riser 5 SLP was operational for the last two days of the mixing campaign. [U-ESR-H-00103]

CSR-II Campaign 2

The second BOA campaign began on June 24, 2013 with approximately 18,000 gallons of 8 wt% acid addition to Tank 12H at a 20:1 acid to sludge ratio and approximately 39,000 gallons of well water for dilution to 4 wt%. From the experience gained during the first campaign, pH was not expected to be an indicator for strike completion so the duration was set at seven days. The mixing strategy for this strike was to focus on reducing the mound under the valve house (east side of the waste tank). The four SLPs were started on June 25, 2013, and operated at maximum speed for the entire operation. The SLPs operated under six different indexing sequences during the second campaign. [U-ESR-H-00103]

A second addendum to the operating plan was issued to reinstate field measurement of pH as the primary method after the sampling procedure was revised and newer, more accurate pH meters were acquired. The pH during the second campaign reached a maximum of approximately 1.5. The Tank 12H to Tank 51H slurry transfer was initiated on July 1, 2013 after seven days of mixing operations and approximately 72,000 gallons were transferred. Between July 2 and 3, 2013, a buffering solution was added to the waste tank to ensure compliance with the corrosion control requirements when dewatering to Tank 11H. A tank inspection was conducted immediately after the transfer to assess the campaign results. [U-ESR-H-00103]

CSR-II Campaign 3

The third BOA campaign began on July 8, 2013 with the addition of approximately 24,000 gallons of 8 wt% acid to Tank 12H and approximately 39,500 gallons of well water for dilution to 4 wt%. The OA to sludge ratio was 20:1, as in the second campaign. The four SLPs were started on July 10, 2013, and operated at maximum speed for the duration of the campaign. The mixing strategy for the third campaign was focused heavily on indexed operation of the SLPs for further reduction of the mound. The SLPs were operated under nine different indexing sequences during this strike. Because pH was not an indicator for strike completion, the duration was set at seven days as in the second strike. Approximately 75,000 gallons of Tank 12H slurry was transferred to Tank 51H on July 16, 2013. Afterwards, the waste tank went through neutralization operations intended to arrest any residual acid attack on tank components. The waste tank was dewatered on July 31, 2013. The residual heel was formally mapped using video inspection footage and a series of high resolution photographs captured from three different elevations with cameras suspended from Riser 8 and the Center Riser. The residual heel was estimated to be less than 2,000 gallons. [U-ESR-H-00103, SRR-CWDA-2013-00125]

3.4.4.4 Summary of CSR-II Campaigns 1 through 3

Tank 12H BOAC consisted of three OA strikes. Each strike was comprised of an addition of 8 wt% OA followed by an addition of well water to reduce the overall OA concentration to less than or equal to 4 wt%. At the completion of each strike and just prior to transferring the acidic material to the neutralization tank (i.e., Tank 51H), two dip samples were taken from the waste tank to be analyzed for dissolved solid species, radiological species, and pH. One sample was sent to the F/H Area laboratory for analysis and one sample was sent to SRNL for analysis. Except for the radiological analysis, the SRNL results were utilized to evaluate the effectiveness of the BOAC dissolution since a more extensive analysis was provided. The heel in Tank 12H was neutralized to a pH of 7 with caustic and well water following the Campaign 2 and Campaign 3 acidic transfers out of Tank 12H. Neutralization was completed to support dewatering of the waste tank while remaining within the control set of the safety basis. The neutralization operations did not remove any appreciable amount of solids. The intent of dewatering was to transfer as much of the neutralized solution out of Tank 12H as possible following Campaign 2 so that the residual material would be exposed to the fresh acid feed during Campaign 3 and to facilitate inspections and volume determination. [SRR-LWE-2013-00202, U-ESR-H-00103]

The updated BOAC flowsheet implemented the following improvement controls:

- The material in Tank 12H was washed prior to BOAC to reduce the sodium concentration to less than 0.5 molar
- The contact rate of the acid with the residual sludge heel was increased by utilizing mixing pumps with targeted mixing strategies to ensure accumulations were broken up, the overall pH of the solution was monitored so that the material could be transferred out of the waste tank before exceeding a pH of 2
- The operating temperature was maintained less than 60°C due to waste tank specific and safety basis related constraints

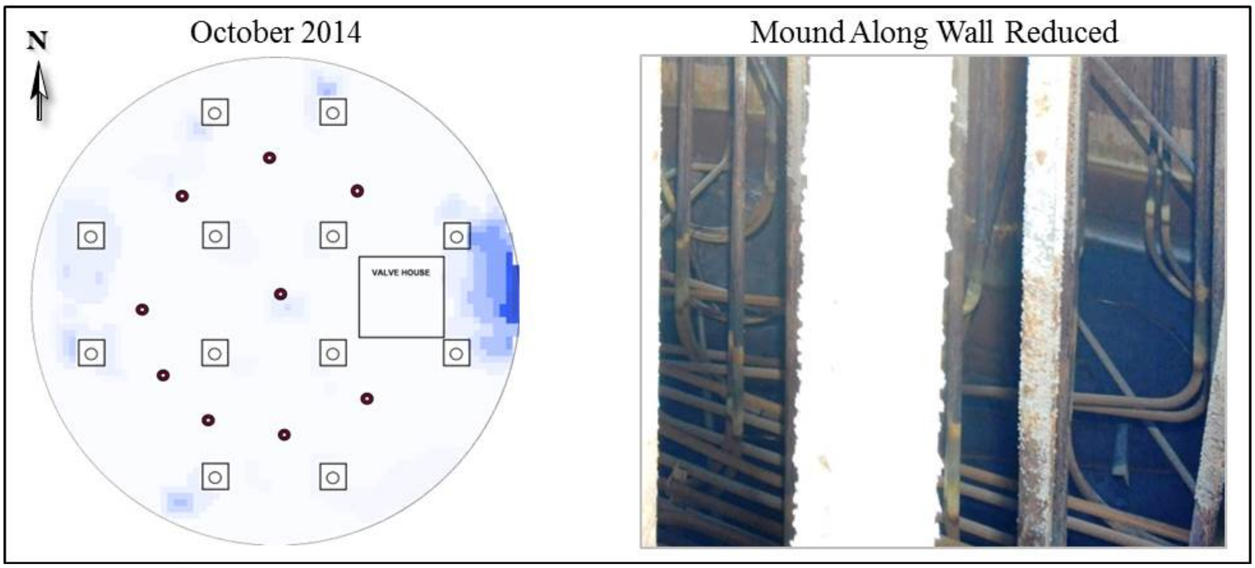
The operational constraints imposed by the safety basis and physical limitations of Tank 12H did not aid in the dissolution efficiency; however, the improvements that were implemented overcame any disadvantageous influence these constraints might have imposed. Specific opportunities that were addressed in the improved operating strategy included:

- Increasing the contact rate of the acid with the residual sludge heel
- Controlling the pH to minimize oxalate precipitation
- Establishing favorable initial conditions for waste removal
- Improving mixing operations during the chemical cleaning evolution

The BOAC process in Tank 12H constituted the final attempt at heel removal for Tank 12H. The method reduced the heel volume from 4,400 gallons to less than 2,000 gallons (a reduction of nearly 55%). The BOAC flowsheet evaluated the potential benefit of additional campaigns but determined that waste removal was expected to be minimal and a potential existed to precipitate oxalates, which would add to the residual volume. After BOAC, the cumulative volume of waste had been reduced by greater than 99%. The total solids volume removed was over 98%. [X-CLC-H-00896, SRR-CWDA-2013-00125]

Figure 3.4-7 shows the mapping results and a photo of the Tank 12H east quadrant (previous location of a mound) after the CSR-II campaign. Tank 12H heel removal related operations during CSR-II are summarized in Table 3.4-4. Figure 3.5-4 shows the Tank 12H waste removal history after the CSR-II campaigns.

Figure 3.4-7: Effectiveness of CSR-II Campaigns 1 through 3



* See Figure 3.1-2 for topographical color scale

Table 3.4-4: Waste Removal Details CSR-II Campaigns 1 through 3

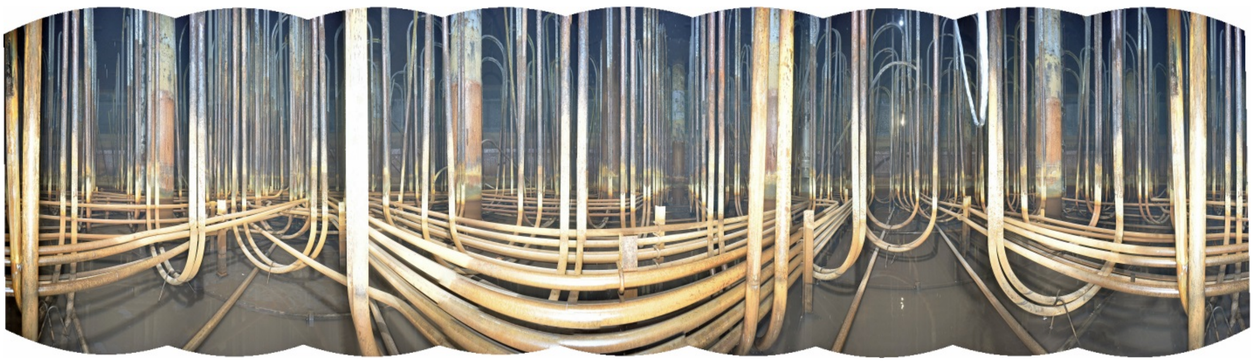
CSR-II Campaign Number	1	2	3
Campaign Duration	06/08/13-06/21/13	06/24/13-07/06/13	07/08/13-07/31/13
SLPs Experiencing Problems	None	None	None
SLP Operating Time (hours)	62 w/ 4 SLPs 123 w/ 3SLPs	136 w/ 4 SLPs	148 w/ 4 SLPs
Other Water Added (gal)	68,000	39,000	39,500
8 wt% OA Added (gal)	64,500	18,000	24,000
Slurry Transferred (gal)	115,000	72,000	75,000
Sludge Remaining (gal)	Unobserved [a]	Unobserved [a]	< 2,000
Solids Removed (%)	Unobserved [a]	Unobserved [a]	> 55
Cumulative Solids Removed (%)	Unobserved [a]	Unobserved [a]	> 99

Note: Due to inconsistencies in reporting, transfer volumes have been rounded to nearest 500 gallons.
[a] Tank level not low enough to observe remaining solids for volume estimate
[SRR-CWDA-2013-00125, SRR-LWE-2013-00202, SRR-LWE-2014-00155, SRR-LWP-2014-00002]

3.5 Tank 12H Tank Waste Removal Summary

Waste removal details for the primary tank are presented in Sections 3.2 through 3.4. Figure 3.5-1 shows a panoramic, 360-degree, view of the Tank 12H primary tank after waste removal. The photograph in Figure 3.5-1 was captured using a high-resolution digital camera suspended below the Center Riser, at an elevation near the tank floor, while approximately three inches of residual liquid was still present in Tank 12H.

Figure 3.5-1: Panoramic View of the Tank 12H Interior (After Waste Removal in September 2013)



A representative, close-up photograph of the final residual heel in the Tank 12H primary tank is shown on Figure 3.5-2. The photograph in Figure 3.5-2 was captured using a high-resolution digital camera suspended below the Center Riser, at an elevation near the tank floor, while approximately three inches of residual liquid was still present in Tank 12H.

Figure 3.5-2: Photograph of Tank 12H Primary Tank Floor (After Waste Removal in September 2013)

The mound along the wall on the east side of the Tank 12H primary tank, which accounts for approximately 50% of the final residual heel by volume, is shown on Figure 3.5-3. The photo in Figure 3.5-3 was taken from the camera on board the crawler while approaching the mound from the north end.

Figure 3.5-3: Photograph of Tank 12H Final Residual Heel Mound (During Sampling in August 2014)

The cooling coils, support columns, and tank primary wall in Tank 12H have a variable coating of solids from the top of the coil down to a level near the midline of the waste tank. Below the midline level, the surfaces are relatively free of solids. To quantify the amount of intact residual solids on the affected surfaces, the volume of material was estimated through a formal engineering calculation. It was estimated that a total of 400 gallons of residual solids remain intact on the external surfaces of the cooling coils, support columns, and tank primary wall in Tank 12H with the majority of the solids on the coils. [M-CLC-H-03256] Material from two coils was sampled and one sample was analyzed. In addition, the Tank 12H annulus was estimated to contain less than 30 gallons of residual material that leaked from the primary tank. Additional discussion on the material on the cooling coils will be provided in the CM addendum.

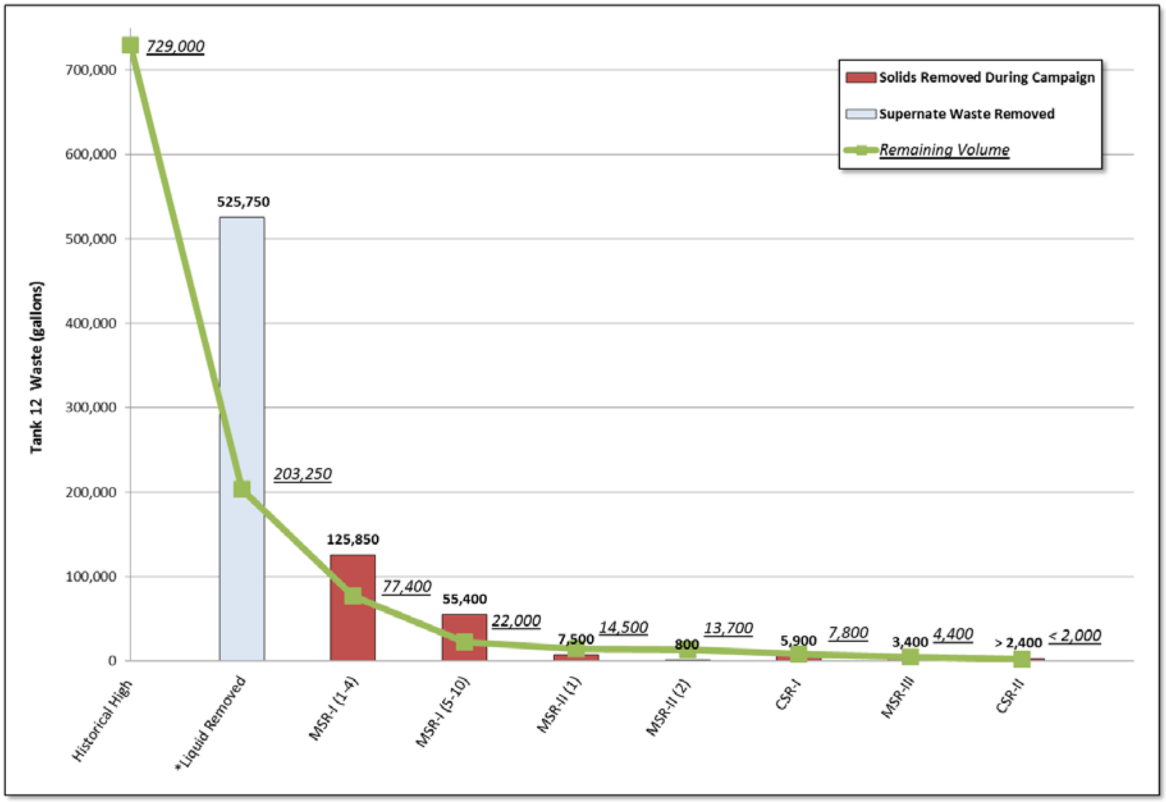
The Tank 12H overall waste removal efforts are summarized in Table 3.5-1. The waste removal effectiveness for Tank 12H is shown on Figure 3.5-4. The percentage of total waste volume removed from the primary tank was calculated to be greater than 99%.

Table 3.5-1: Tank 12H Waste Removal Summary

Total Starting Volume (gallons)	~729,000 [a]
Total Liquid Introduced into the Tank (gallons)	~2,500,000
Total Solids Removed (gallons)	> 201,250
Total Solids Remaining (gallons)	< 2,000
Percent of Total Waste Volume Removed (%)	**> 99**

[a] Starting volume is based on historical high waste volume in the tank

Figure 3.5-4: Tank 12H Waste Removal by Phase



3.6 Basis to Proceed with Sampling and Analysis Activities in Tank 12H

Heel removal operations were completed in the primary tank as described in Section 3.4. The qualitative determination to suspend heel removal activities for the Tank 12H primary tank was primarily based on visual observation. Visual inspections inside the primary tank, utilizing remotely operated cameras, showed there was a significant reduction in residual material volume as a result of waste removal efforts. At the time of the decision to proceed with sampling, the volume of residual material in the primary tank was estimated to be less than 2,000 gallons. The final residual material volume determination, which is performed at the completion of residual sampling, will be discussed in the CM addendum. [SRR-CWDA-2013-00125]

3.7 Agreement to Proceed with Sampling and Analysis

The FFA requires DOE to notify EPA and SCDHEC when DOE considers waste removal to be complete and to provide any supporting documentation to SCDHEC and EPA for review. DOE, SCDHEC, and EPA shall mutually agree that waste removal activities may cease.

DOE informed SCDHEC and EPA on December 19, 2013, regarding the status of Tank 12H. [SRR-CWDA-2013-00125]

The briefing demonstrated that:

- The mechanical and chemical waste removal technologies were effective in Tank 12H and had been utilized to the maximum extent practicable from an engineering perspective to remove significant additional waste
- Over 99% of the waste by volume in Tank 12H had been removed
- A qualitative assessment of additional cleaning options indicates that additional waste removal efforts are not practicable. Additional removal efforts would have a high cost and a high potential for dose to workers and members of the public. The benefit of additional removal efforts would be miniscule.
- A qualitative assessment indicates that at the current waste tank status, 10 Code of Federal Regulations (CFR) 61, Subpart C performance objectives would be met

Following the briefing, DOE sent the formal *Request for Concurrence to Proceed to Sample and Analysis Phase of the Tank Closure Process for Tank 12H*. [WDPD-14-20]

Agreement was reached between the three agencies that waste removal efforts could be suspended and DOE could proceed with sampling and analysis activities for Tank 12H to characterize the residual waste. SCDHEC and EPA submitted letters to DOE stating:

> *"…based upon the qualitative information provided, there is reasonable assurance that it is appropriate to enter the sampling and analysis phase of the closure process for Tank 12H. Full sampling and analysis of the residuals in support of the Closure Module for the referenced tanks* [sic] *will be needed before a final decision can be made by the Department regarding completion of waste removal operations for Tank 12H."* [DHEC-OS-2014-02-18-01]
>
> and
>
> *"Based on the information provided in the briefing and in DOE's letter, EPA concurs with DOE's request to cease waste removal activities in Tanks* [sic] *12H and proceed with the sampling and analysis phase of the project."* [EPA-OS-2014-02-19-01]

4.0 RESIDUAL MATERIALS CHARACTERIZATION

After receiving letters from EPA and SCDHEC agreeing with DOE to suspend waste removal, DOE initiated activities to characterize the Tank 12H residual material to determine the chemical and radiological constituent inventories and validate the HTF PA modeling. The overall characterization process for Tank 12H is anticipated to take approximately two years (duration includes time from completion of BOAC to issuance of a final residual inventory determination report). The tank residuals characterization process consists of activities including, but not limited to, evaporation of residual liquid in the primary tank to a level such that residual material samples can be obtained; riser preparations to insert sampling equipment into the primary tank; sampling tool development; sampling work package development and equipment mock-up testing; sampling of the residual materials; chemical and radiological laboratory sample analyses; sample analytical report development; and development of the final waste tank residual inventory determination. The overall RFS schedule for Tank 12H is determined by the residual materials characterization process. Sampling and final characterization of the residual materials is in accordance with the *Liquid Waste Tank Residuals Sampling and Analysis Program Plan* (LWTRSAPP) and *Liquid Waste Tank Residuals Sampling – Quality Assurance Program Plan* (LWTR-QAPP) that were reviewed and approved by SCDHEC and EPA. [SRR-CWDA-2011-00050, SRR-CWDA-2011-00117]

As described in Section 1.0, to improve (i.e., shorten) the RFS schedule for Tank 12H, DOE, SCDHEC, and EPA agreed to use a two-step approach for development and approval of the Tank 12H CM. Since analyses of the Tank 12H residual waste are currently on-going, final results are not available for inclusion in this CM. The first step is to prepare and obtain conditional SCDHEC approval of this CM which uses a forecasted (i.e., not final) Tank 12H residual inventory, as described in this CM section. The second step of the approach will present the Tank 12H final inventory and the results of the Tank 12H SA using the final inventory in an addendum to this CM. The Tank 12H SA will be developed comparing the final Tank 12H inventory determination with the forecasted inventory used in this CM.

The Tank 12H forecasted residual inventory has been included in the modeling performed for *Tank 16 Special Analysis for the Performance Assessment for the H-Area Tank Farm at the Savannah River Site* (SRR-CWDA-2014-00106). The Tank 16H SA includes the fate and transport modeling results using both the final Tank 16H residual inventory and the Tank 12H forecasted residual inventory. Results applicable to Tank 12H from the Tank 16H SA are presented in Section 5.0 of this CM. The Tank 16H SA results provide reasonable assurance that the HTF GCP performance objectives will be met for closure of HTF throughout the 1,000-year DOE compliance period for the Tank 16H final inventory and the Tank 12H forecasted inventory source terms remaining in the waste tanks.

Table 4.0-1 provides a summary of the steps associated with Tank 12H residual waste characterization information and where (i.e., in this CM or in the addendum) the characterization information will be documented.

Table 4.0-1: Summary of Residual Material Characterization Steps

Residual Material Characterization Step	Description	Tank 12H CM	Tank 12H CM Addendum
Residuals Volume Determination	Describes how the residual material volumes are determined	Includes 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)	Will include the final volume determination based on additional photographs and video obtained during the tank sampling that augment the preliminary mapping and volume estimate
Residual Materials Characterization	Describes the approaches used for the residual materials characterization, the sample collection techniques, the materials sampled, and the final sample locations	Although Tank 12H sampling and analysis activities are well underway, the final characterization information is not available for this CM development	Will include discussion on final residuals sample collection techniques, tools, locations, and analytical sample compositing
Derivation of Constituents of Concern and Analytes	Describes the process for determining the chemical and radiological constituents of concern and the screening process for the analyte lists used to characterize the residual materials	Discusses and presents the chemical and radiological constituents of concern developed for Tank 12H	Will reference the same chemical and radiological constituents of concern used in the Tank 12H CM
Sample Analyses	Describes the residual material sample analyses and references the laboratory report for details	Although Tank 12H sampling and analysis activities are well underway, the final characterization information is not available for this CM development	Will include the reported analytical results, the Data Quality Assessment discussion, and the data used for the final inventory determination
Inventory Determination	Describes how the final residual volumes and the sample analysis results are used to determine the radiological and chemical inventory	The CM uses a forecasted Tank 12H inventory and includes a discussion of the bases used for the forecasted inventory	Will include the final inventory determination based on analytical results and the final residuals volume determination

4.1 Preliminary Residuals Volume Estimate Used for the Forecasted Inventory

As discussed in Section 3.6, this CM uses a preliminary residuals volume estimate of less than 2,000 gallons consistent with the presentation: *Proposal to Cease Waste Removal Activities in Tank 12 and Enter Sampling and Analysis Phase* (SRR-CWDA-2013-00125).

Based on visual inspections, the Tank 12H annulus contains less than 30 gallons of residual material introduced by leak sites through the primary tank wall. A volume of 100 gallons was initially assigned as part of HTF PA development. To be conservative, the 100 gallon volume estimate was maintained for the forecasted inventory.

The final residual material volume determination, which is performed at the completion of residual sampling, will be presented and discussed in the CM addendum.

4.2 Derivation of Constituents of Concern and Analytes

Potential chemical and radiological constituents in the waste tanks are known by tracking waste data based on sample analysis, process histories, composition studies, and theoretical relationships. The most current listing of the chemical and radiological constituents found in tank waste is in *Information on the Radiological and Chemical Characterization of the Savannah River Site Tank Waste as of July 5, 2011* (SRR-LWE-2011-00201), which includes constituents that were received into the FTF or HTF over the facility history as well as any constituents that could have formed in the tank sludge, salt, or supernate phases. The referenced report was used to develop the list of chemical and radiological constituents in the tank residuals. The inventories reported in the referenced document are based on best available information or estimated values used to support liquid waste management safety and operational decisions. Because this information is used for safety purposes (e.g., nuclear criticality evaluations, corrosion evaluations), the estimates are approximate and may overestimate or underestimate the actual inventories (i.e., may be conservative, and not reflect actual lower or higher inventories).

Because the source of the material in the annulus was leakage from the primary tank, the analyte list for the annulus inventory determination was the same as for the primary tank.

The derivation of the final chemical and radionuclide constituents of concern is described below. As summarized in Table 4.0-1, the list of Tank 12H chemical and radionuclide constituents of concern is the same for the forecasted inventory used in this CM and the final inventory to be presented in the CM addendum.

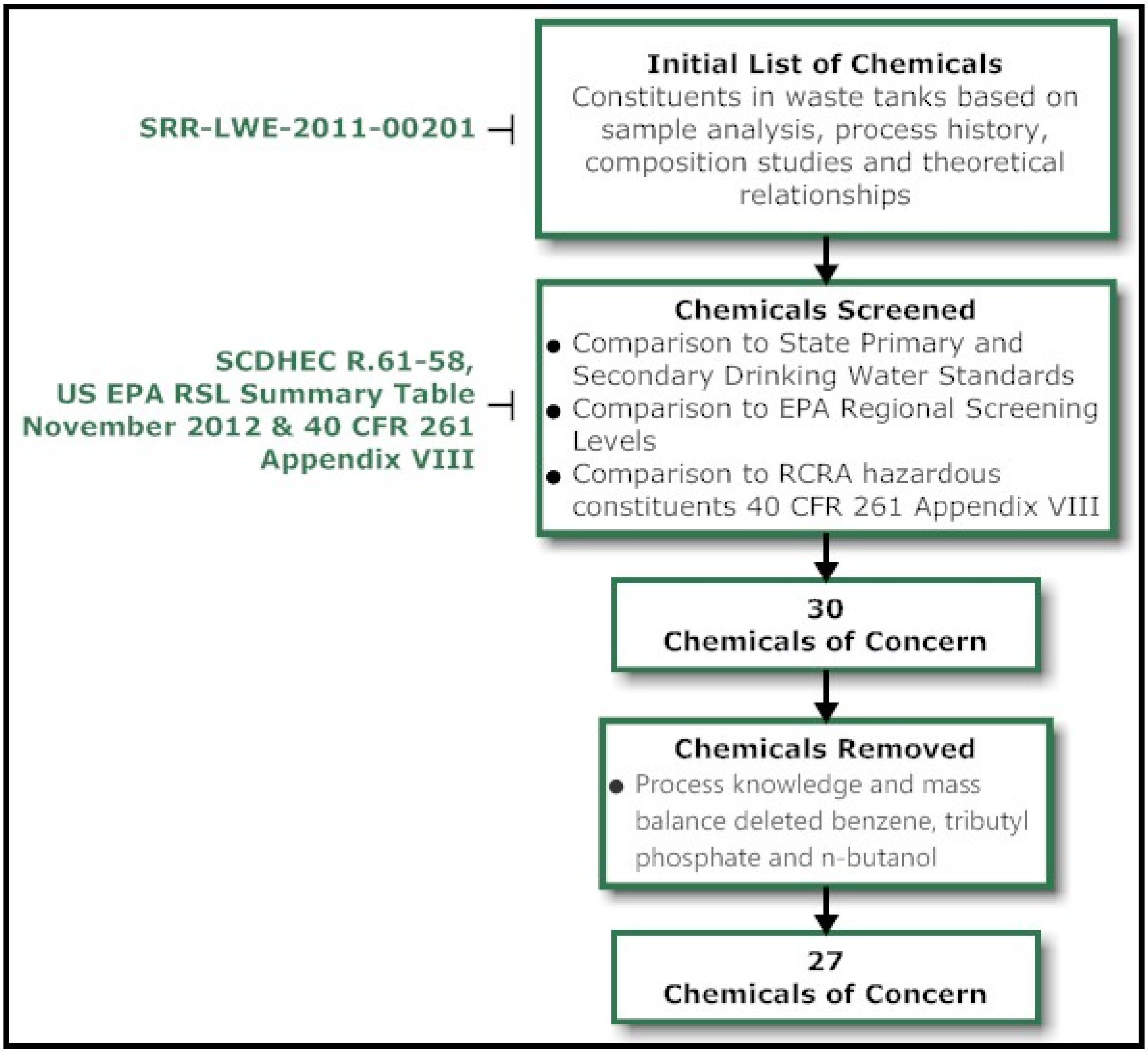
4.2.1 Chemical Constituent Screening and Analyte List

The chemical constituents of interest were identified through a screening process using EPA Regional Screening Levels (RSLs) from November 2012, maximum contaminant levels (MCLs) from the State Primary Drinking Water Regulations for inorganic contaminants specified in SCDHEC R.61-58, and hazardous constituents from 40 CFR 261 Appendix VIII. The chemical constituents expected to be present in the waste tanks were compared to the list of chemicals that had RSLs, MCLs, or hazardous characteristics and if any of the tank farm chemicals were present on any of the lists, the chemical was added to the list of chemicals of concern. [SRR-CWDA-2014-00052]

The chemicals of concern list was further evaluated to determine which constituents could be removed based on process knowledge. Tributyl phosphate, benzene, and n-butanol were removed based on Tank 12H process knowledge. [SRR-CWDA-2014-00052]

The overall screening process yielded 27 chemical constituents for Tank 12H that will have a forecasted inventory based either on process sample analysis and/or process knowledge. The screening determination process is shown on Figure 4.2-1 and the Tank 12H chemical analytes are listed in Table 4.2-1.

Figure 4.2-1: Screening Determination Process for Tank 12H Chemical Analytes



[SRR-CWDA-2014-00052]

Table 4.2-1: Chemical Analyte List for Tank 12H Samples

Chemical Analytes		
Aluminum	Copper	Nitrate
Arsenic	Fluoride	Nitrite
Antimony	Iodine	Phosphate
Barium	Iron	Selenium
Boron	Lead	Silver
Cadmium	Manganese	Strontium
Chloride	Mercury	Sulfate
Chromium	Molybdenum	Uranium
Cobalt	Nickel	Zinc

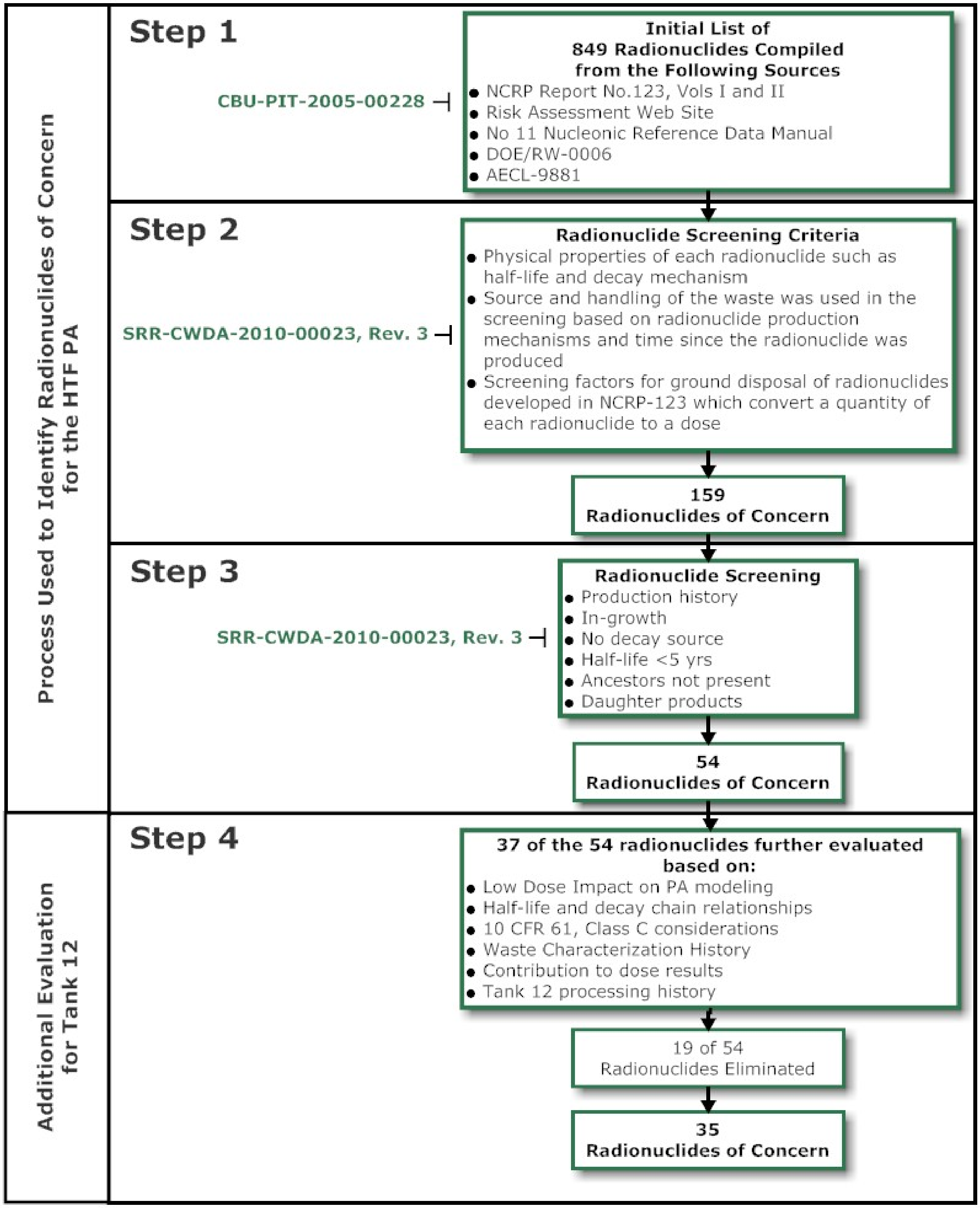
4.2.2 Radiological Constituent Screening and Analyte List

The overall screening process to determine potential radionuclide contaminants for the HTF is described in Section 5.1 of the HTF GCP. [SRR-CWDA-2011-00022] The analytes included potential radionuclides and any radionuclide daughters that may be present in the waste tank. The initial screening evaluated 849 radionuclides. Of the original 849 radionuclides, 159 remained on the list and 690 were excluded from further consideration for various reasons (e.g., short half-life, no HTF applicable production history, low risk) as explained in the *H-Tank Farm Waste Tank Closure Inventory for Use in Performance Assessment Modeling* (SRR-CWDA-2010-00023, Rev. 3), hereafter called the HTF PA Inventory Document. Additional screening was performed for the remaining 159 isotopes based on the presence/absence of parent radionuclides. The result of these two screening processes yielded a list of 54 radionuclides for the HTF. The screening process that reduced the initial 849 radionuclides to 54 radionuclides is briefly described in Steps 1 through 3 on Figure 4.2-2. Additional detail on Steps 1 through 3 can be found in Appendices A and B of the HTF PA Inventory Document. [SRR-CWDA-2010-00023, Rev. 3]

The 54 radionuclide analyte list was further reduced by eliminating 19 radionuclides expected to have an insignificant impact on the Tank 12H radionuclide release modeling results. This evaluation process is shown as Step 4 on Figure 4.2-2. This left a total of 35 radionuclides of concern for Tank 12H sample analysis. [SRR-CWDA-2014-00052]

For the purposes of the Tank 12H screening, insignificant impact was defined as radionuclides that individually contribute less than 5.0E-02 millirem per year total effective dose equivalent (TEDE) (mrem/yr) to the peak HTF member of the public (MOP) in the first 20,000 years following operational closure (year 2032) as documented in the HTF PA Revision 1, Table 5.2-9 using assigned radionuclide inventories. [SRR-CWDA-2010-00128]

Figure 4.2-2: Screening Determination Process for Tank 12H Radionuclide Analytes



[SRR-CWDA-2014-00052]

The results of the latest HTF PA modeling identified 35 radionuclides meeting this criterion. Each of these radionuclides was further evaluated to identify any other rationales for retaining them on the Tank 12H analyte list. This additional evaluation looked at the following:

- The half-life associated of the radionuclide and decay chain relationships
- Additional regulatory requirements (e.g., Class C compliance)
- If the radionuclide is identified as a Highly Radioactive Radionuclide (HRR) in the *Draft Basis for Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site* (DOE-SRS-WD-2013-001)
- The radionuclide's contribution to dose results in the HTF PA (i.e., MOP dose, inadvertent intruder dose, and airborne dose)

Based on the screening processes described above, the Tank 12H radiological constituents of interest (i.e., constituents requiring analysis and characterization) are listed in Table 4.2-2.

Table 4.2-2: Radionuclide Analyte List for Tank 12H 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	

4.3 Forecasted Residual Inventory Development

This CM was developed using a forecasted residual radiological and chemical inventory for Tank 12H. The initial assigned Tank 12H inventory used in the HTF PA in 2010 was updated using available process information obtained during Tank 12H waste removal and a preliminary estimate of the residual material volume.

4.3.1 Background on Initial Assigned Tank 12H Inventory Developed for Use in the HTF PA

An initial Tank 12H radiological and chemical inventory was established as part of the HTF PA. Initial assigned inventories were developed for all HTF waste tanks using historic residual material concentrations and volume estimates. The concentration for each Tank 12H constituent was estimated by using the WCS electronic information system that tracks inventory data for all SRS waste tanks, including projected radiological and chemical inventories, using sample analyses, process histories, composition studies, and theoretical relationships. The WCS system tracks the projected dry sludge concentrations of 40 radionuclides and 37 chemical compounds.

To account for uncertainty in future HTF operations and material movements, a final adjustment was made to the initial inventories to add additional conservatism. During this adjustment, Tank 12H was grouped according to waste tank use and design with the other Type I and Type II Tanks (excluding Tank 16H due to its unique processing history). The maximum inventory of each radionuclide or chemical in any tank within a group was applied to the other tanks within the group. The Tank 12H radiological and chemical inventory used in HTF PA modeling is documented in *H-Area Tank Farm Closure Inventory for Use in Performance Assessment Modeling*. [SRR-CWDA-2010-00023, Rev. 3]

Based on previous waste removal experience, the assigned HTF PA volume for the Tank 12H primary tank residual material was conservatively estimated at 4,000 gallons. Because the Tank 12H annulus contains less than 30 gallons of residual material from leak sites through the primary tank wall, a conservative volume of 100 gallons was assigned as part of HTF PA development.

4.3.2 **Development of Tank 12H Forecasted Residual Inventory**

The Tank 12H initial assigned inventory values used in the HTF PA were updated using the latest available process information obtained during Tank 12H waste removal. The initial assigned radiological and chemical inventories were adjusted, where applicable, to derive the Tank 12H forecasted residual inventory. While some inventory values were revised upward, no attempt was made to decrease forecasted inventory assignments. This philosophy provided conservatism in the forecasted residual inventory values. The radiological and chemical constituents tracked in the Tank 12H forecasted inventory were selected as described in the *Recommended Radionuclide and Chemical Analyte List for Tank 12*. [SRR-CWDA-2014-00052]

During June and July 2013, Tank 12H underwent BOAC campaigns. To support an effort to evaluate BOAC effectiveness, several process samples were collected. These process samples included a pre-BOAC residual solids sample and numerous liquid samples taken during BOAC. The cleaning efficiency was evaluated and documented in *Effectiveness of Tank 12 Bulk Oxalic Acid Cleaning (BOAC)*. [X-ESR-H-00599] An estimate of the inventory remaining on the Tank 12H floor after BOAC was made by comparing the inventory estimated prior to BOAC with the total activity removed.

Where available and applicable, post-BOAC estimated inventory information was used to inform the Tank 12H forecasted residual inventory. [X-ESR-H-00599]

Since the final Tank 12H volume determination is not completed, the post BOAC inventories were conservatively doubled for the forecasted inventory to account for the final volume uncertainty. For example, the Tank 12H primary tank had an assigned Np-237 inventory of 0.21 curies in the HTF PA. [SRR-CWDA-2010-00128] The sampling data from *Effectiveness of Tank 12 Bulk Oxalic Acid Cleaning (BOAC)* (X-ESR-H-00599) (i.e., the Tank 12H scrape sample data, Table 25) indicated there could be up to 0.36 curies of Np-237 remaining in Tank 12H. Based on this data, the HTF PA initial assigned Np-237 inventory was increased to 0.72 curies (double the 0.36 curies).

A detailed discussion on each of the Tank 12H radionuclide and chemical inventory adjustments is provided in the latest HTF PA Inventory Document. [SRR-CWDA-2010-00023, Rev. 4]

As noted in Section 4.1, the forecasted inventory was developed prior to the final volume determination. The volume uncertainty was taken into account by using a volume of 2,000 gallons. A final volume determination will be performed using additional sample crawler and riser photographs and videos taken during sampling activities.

In addition to the residual material on the primary tank floor, the cooling coils in Tank 12H are coated with an estimated 400 gallons of a scale material. [M-CLC-H-03256] This material is located above the former liquid level associated with bulk waste removal efforts and chemical cleaning activities. The scale material is thought to be a residue that adhered to and/or accumulated on the coils, potentially as a result of the temperature delta between the coils and liquid waste. The scale material was not addressed in the initial assigned Tank 12H HTF PA inventory. The preliminary analysis on one coil material sample shows the material contains a high concentration of mercury. [SRNL-L3100-2014-00256] To account for the inventory uncertainty for the cooling coil scale material, the forecasted mercury inventory was arbitrarily increased from 2,400 kg to 4,500 kg. No other Tank 12H forecasted inventory changes are proposed based on the coil material analysis. [SRR-CWDA-2010-00023, Rev. 4]

The forecasted Tank 12H annulus inventory also incorporates updated process knowledge (i.e., Tank 16H annulus sample analyses) for the Tank 12H annulus material. To be conservative, the initially assigned HTF PA volume estimate of 100 gallons was maintained for the Tank 12H forecasted inventory.

4.4 Forecasted Residual Inventories

The Tank 12H forecasted residual inventories for radiological and chemical constituents of concern are shown in Tables 4.4-1 and 4.4-2, respectively. The Forecasted Inventory (2032) column represents the radionuclide inventories that have been decay-corrected to 2032 for comparison to the 2032 inventory used in the HTF PA modeling. No decay correction is necessary for the chemicals. The basis for the 2032 date used by the HTF PA was the *Liquid Waste System Plan* (SRR-LWP-2009-00001, Rev. 15) in place at the time of HTF PA development. [SRR-CWDA-2010-00023, Rev. 3]

The 2032 Tank 12H forecasted inventories in Tables 4.4-1 and 4.4-2 are used in the Tank 16H SA as discussed in Section 5.0.

Table 4.4-1: Tank 12H Primary Tank Radionuclide Residual Material Forecasted Inventories

Constituent	Units	Primary Tank Forecasted Inventory (2032)	Annulus Forecasted Inventory (2032)
Ac-227	Ci	0.0E+00	0.0E+00
Al-26	Ci	0.0E+00	0.0E+00
Am-241	Ci	7.0E+02	9.8E-02
Am-242m	Ci	1.0E+00	4.9E-05
Am-243	Ci	3.0E+00	1.0E-04
Ba-137m	Ci	2.4E+03	4.6E+01
C-14	Ci	1.0E+00	6.4E-05
Cf-249	Ci	0.0E+00	0.0E+00
Cf-251	Ci	0.0E+00	0.0E+00
Cl-36	Ci	0.0E+00	0.0E+00
Cm-243	Ci	1.0E+00	1.8E-04
Cm-244	Ci	2.0E+01	5.1E-03
Cm-245	Ci	1.0E+00	9.7E-07
Cm-247	Ci	0.0E+00	0.0E+00
Cm-248	Ci	0.0E+00	0.0E+00
Co-60	Ci	0.0E+00	0.0E+00
Cs-135	Ci	5.4E-03	2.6E-04
Cs-137	Ci	2.5E+03	4.9E+01
Eu-152	Ci	0.0E+00	0.0E+00
Eu-154	Ci	0.0E+00	0.0E+00
H-3	Ci	0.0E+00	0.0E+00
I-129	Ci	2.6E-02	1.0E-04
K-40	Ci	0.0E+00	0.0E+00
Nb-94	Ci	1.1E-01	3.4E-05
Ni-59	Ci	8.6E+00	1.2E-04
Ni-63	Ci	6.3E+02	4.7E-03
Np-237	Ci	7.2E-01	2.7E-04
Pa-231	Ci	2.1E-03	2.0E-05
Pd-107	Ci	0.0E+00	0.0E+00
Pt-193	Ci	0.0E+00	0.0E+00
Pu-238	Ci	9.8E+03	3.9E-01
Pu-239	Ci	3.9E+02	6.2E-02
Pu-240	Ci	3.9E+02	2.8E-02
Pu-241	Ci	2.5E+03	7.6E-02
Pu-242	Ci	0.0E+00	0.0E+00
Pu-244	Ci	0.0E+00	0.0E+00
Ra-226	Ci	2.1E-02	1.4E-05
Ra-228	Ci	2.1E+00	5.3E-02

Table 4.4-1: Tank 12H Primary Tank Radionuclide Residual Material Forecasted Inventories (Continued)

Constituent	Units	Primary Tank Forecasted Inventory (2032)	Annulus Forecasted Inventory (2032)
Se-79	Ci	0.0E+00	0.0E+00
Sm-151	Ci	0.0E+00	0.0E+00
Sn-126	Ci	4.6E+00	4.6E+00
Sr-90	Ci	1.3E+05	1.3E+02
Tc-99	Ci	1.2E+01	2.5E-02
Th-229	Ci	2.1E-03	5.3E-05
Th-230	Ci	2.1E-02	4.8E-06
Th-232	Ci	5.5E-02	7.1E-04
U-232	Ci	2.1E-02	5.3E-05
U-233	Ci	3.3E+00	1.5E-04
U-234	Ci	1.7E+00	1.6E-04
U-235	Ci	2.1E-02	2.3E-06
U-236	Ci	0.0E+00	0.0E+00
U-238	Ci	1.8E-01	1.0E-05
Y-90	Ci	1.3E+05	1.3E+02
Zr-93	Ci	4.0E-01	1.1E-02

Table 4.4-2: Tank 12H Primary Tank Chemical Residual Material Forecasted Inventories

Constituent	Units	Primary Tank Forecasted Inventory (2032)	Annulus Forecasted Inventory (2032)
Ag	kg	5.3E+00	3.0E-03
Al	kg	2.5E+03	6.6E+00
As	kg	1.4E-01	2.3E-04
B	kg	3.6E+01	4.3E-02
Ba	kg	2.3E+01	2.0E-02
Cd	kg	1.5E+01	3.1E-03
Cl	kg	1.0E+02	6.1E-02
Co	kg	2.1E-01	2.6E-02
Cr	kg	2.4E+01	2.7E-02
Cu	kg	1.6E+01	1.4E-01
F	kg	1.4E+01	2.5E-02
Fe	kg	3.0E+03	3.0E+00
Hg	kg	4.5E+03	2.2E-01
I	kg	5.0E-01	3.5E-04
Mn	kg	3.2E+03	3.1E-02
Mo	kg	3.6E+01	3.3E-02
Ni	kg	3.9E+02	4.6E-02
NO_2	kg	3.5E+03	5.8E+00
NO_3	kg	3.2E+02	5.0E+00
Pb	kg	5.0E+01	1.2E-01
PO_4	kg	8.8E+00	2.5E-02
Sb	kg	6.0E+00	6.4E-02
Se	kg	1.1E-02	1.1E-03
SO_4	kg	4.4E+01	8.8E-01
Sr	kg	1.1E+01	5.7E-03
U	kg	4.0E+02	2.1E-01
Zn	kg	6.0E+00	4.1E-02

5.0 PERFORMANCE EVALUATION

The HTF PA was prepared to support closure of the HTF underground radioactive waste tanks and ancillary structures. [SRR-CWDA-2010-00128] The purpose of the HTF PA is to evaluate the potential impact on human health and the environment by modeling the residual contaminant release from waste tanks and ancillary structures that have been stabilized with grout. Therefore, the assumed contaminant inventory is the starting point for modeling the contaminant release. A methodical approach was used to construct projections of HTF waste tank system closure inventories to be used in PA modeling. This approach considered current waste tank inventories, uncertainties in the effectiveness of tank cleaning technologies, laboratory detection limits, decay products, and half-lives of radionuclides. The HTF inventory projection for the HTF PA is provided in *H-Tank Farm Closure Inventory for use in Performance Assessment Modeling*. [SRR-CWDA-2010-00023, Rev. 3]

The PA provided the technical basis and results to be used to evaluate residual contaminant status over time. An integrated conceptual model (ICM) was prepared for the PA to evaluate the performance of the HTF following RFS of all waste tanks and ancillary structures. This ICM is used to evaluate the migration of contaminants from the HTF over time. The ICM comprises three related conceptual flow models that represent the HTF and the environmental media through which contaminants may migrate: 1) closure cap model, 2) vadose zone model, and 3) saturated zone model.

The ICM simulates the release of radiological and chemical contaminants from the underground waste tanks and associated ancillary structures in the HTF as well as the migration of the contaminants through soil and groundwater. An independent waste release sub-model was used in the HTF PA to simulate the contaminant release from the stabilized waste tanks, based on various chemical phases in the waste tank controlling solubility and thereby affecting the timing and rate of release of the residual inventory. The ICM also considers the integrity of the waste tank steel liners and cementitious barriers in waste tank modeling, with the barriers degrading over time. As discussed in Section 4.2.2.2.6 of the HTF PA, Tanks 12H, 14H, 15H, and 16H are modeled as "degraded" (i.e., no liners or residual liner materials, such as iron oxides, are assumed to be present in the PA modeling for these waste tanks). The modeling assumption that no carbon-steel primary tank liner or five-foot high annulus pan exist is especially conservative for fast moving or short-lived contaminants such as I-129 and Sr-90, respectively, since infiltrating water would immediately transport the contaminants through the closed tank system (i.e., closure grout and tank vault) to the saturated zone. In the ICM, carbon steel liner failure triggers the contaminant release from the waste tanks. After failure, the liner is not assumed to exist, or otherwise retard flow. The flow into and out of the stabilized residual material is impacted by the material properties of the waste tank cementitious materials. The expected degradation rate and timing for the waste tank cementitious materials is modeled in the ICM. The ICM also simulates the impact of the cementitious materials and soil on contaminant transport. The waste tank ICM within the HTF PA that represents the most probable and defensible estimate of expected release and transport conditions based on currently available information is referred to as the Base Case.

Based on the final residual material inventory for Tank 16H and new process data (i.e., Tank 12H process sample results), the inventories for Tank 16H and the remaining HTF waste tanks and ancillary structures were adjusted to reflect updated residual material inventory information where applicable. [SRR-CWDA-2010-00023, Rev. 4] The final residual material inventory from Tank 16H, along with the adjusted inventory assignments for the remainder of the waste tanks and ancillary equipment in HTF, were evaluated in the Tank 16H SA. The purpose of a special analysis is to confirm that new and updated information (e.g., actual inventories and updated inventory projections) does not change the conclusions regarding the impact of the closure actions. [SRR-CWDA-2014-00106] The HTF ICM used in the Tank 16H SA was essentially the same as that used in HTF PA, with the transport model being slightly modified for the Tank 16H SA to better segment the annulus inventory from the sand layers inventories for applicable waste tanks. The modeling runs performed for the Tank 16H SA used the updated HTF inventories and updated distribution coefficients reflecting the most currently available test results from *Qualification and Management of K_d Data for Use in C&WDA Performance Assessments* (SRR-CWDA-2011-00106). The Tank 16H SA results applicable to Tank 12H are presented in this section.

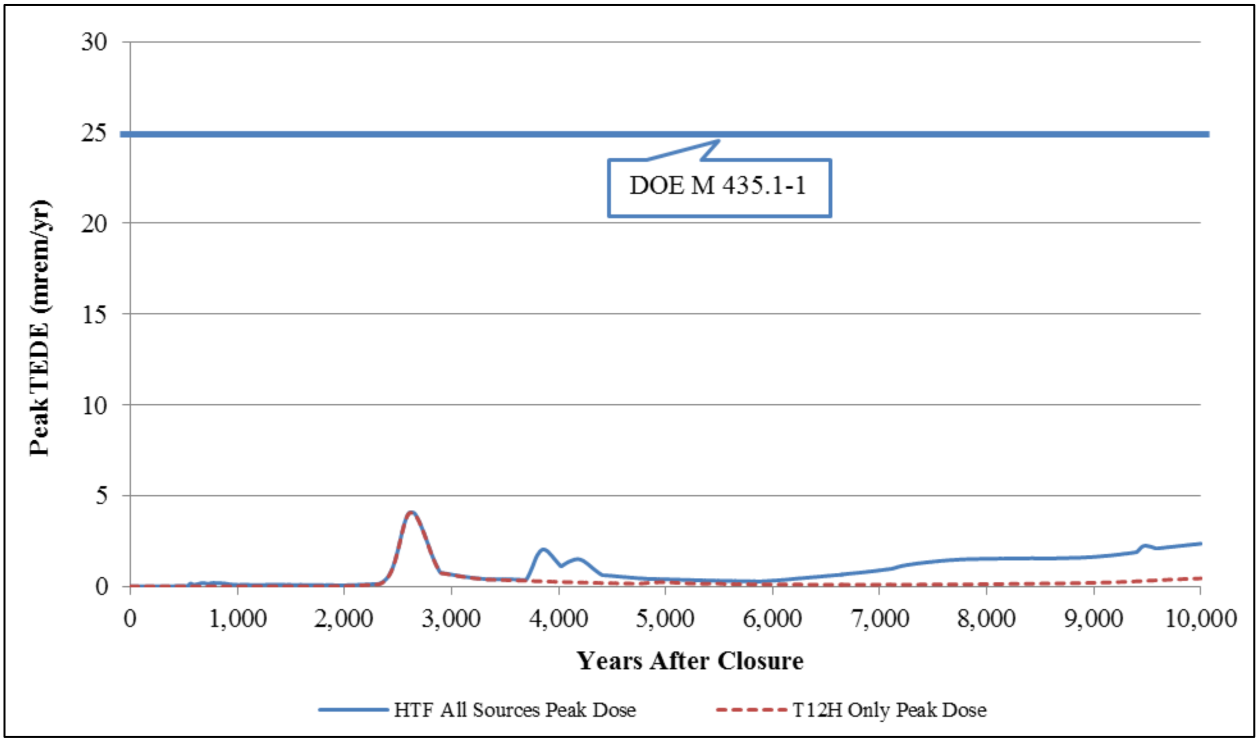
In summary, the Tank 16H SA modeling used:

- A forecasted residual inventory for Tank 12H
- The final residual inventory for Tank 16H
- Revised residual inventory assignments for remaining HTF waste tanks and ancillary structures to reflect updated residual material inventory information, where applicable (SRR-CWDA-2010-00023, Rev. 4)
- The same deterministic (PORFLOW) and probabilistic (GoldSim) models that were developed for the HTF PA (SRR-CWDA-2010-00128) with modified inventory segmentation and updated distribution coefficients, where applicable

The Tank 16H SA provides peak groundwater concentration results within a 1,000-year time period. The *Radioactive Waste Management Manual* (DOE M 435.1-1) establishes a DOE compliance period of 1,000 years for quantitatively assessing whether there is reasonable assurance that performance objectives will be met. DOE has also evaluated groundwater concentrations beyond this 1,000-year DOE compliance period to qualitatively assess risk and evaluate the conclusions regarding reasonable assurance that performance objectives will be met within the 1,000-year period. Figure 5.0-1 shows the Tank 16H SA modeling results over a 10,000 year time period. DOE utilizes a MOP exposure pathway dose methodology to convert radionuclide concentrations to TEDE values for comparison against performance objectives utilizing the most recent dose conversion factors (DCFs), elemental transfer factors, and individual consumption rates as documented in the HTF PA (Section 4.2.3.1, *Member of the Public Exposure Pathways*) and updated in the applicable SA. The methodology used in calculating TEDE for DOE M 435.1-1 assessment includes multiple dose pathways (e.g., water, vegetable, and beef ingestion), in comparison to the radiological beta-gamma dose calculated for the state drinking water standard (Tables 5.1-1 and 5.1-2) that is an annual dose equivalent based solely on water ingestion.

For the HTF Base Case model, Tank 12H, with the forecasted residual inventory, does not contribute significantly to the modeled groundwater peak TEDE within the 1,000-year DOE compliance period, as shown on Figure 5.0-1 and discussed in Section 6.0 of the Tank 16H SA. However, within the 10,000 year time period shown in Figure 5.0-1, the modeled groundwater peak TEDE of approximately 4 mrem/year is attributed to Tank 12H. As shown on Figure 5.0-1, the TEDE contribution from Tank 12H coincides with the overall HTF peak dose. The HTF all sources peak TEDE and Tank 12H only peak TEDE are both well below the applicable *Radioactive Waste Management Manual* (DOE M 435.1-1) performance objective (i.e., dose to representative MOPs shall not exceed 25 mrem in a year TEDE from all exposure pathways) and the *Radiation Protection of the Public and the Environment* (DOE O 458.1) public dose limit of 100 mrem in a year. [DOE M 435.1-1, DOE O 458.1]

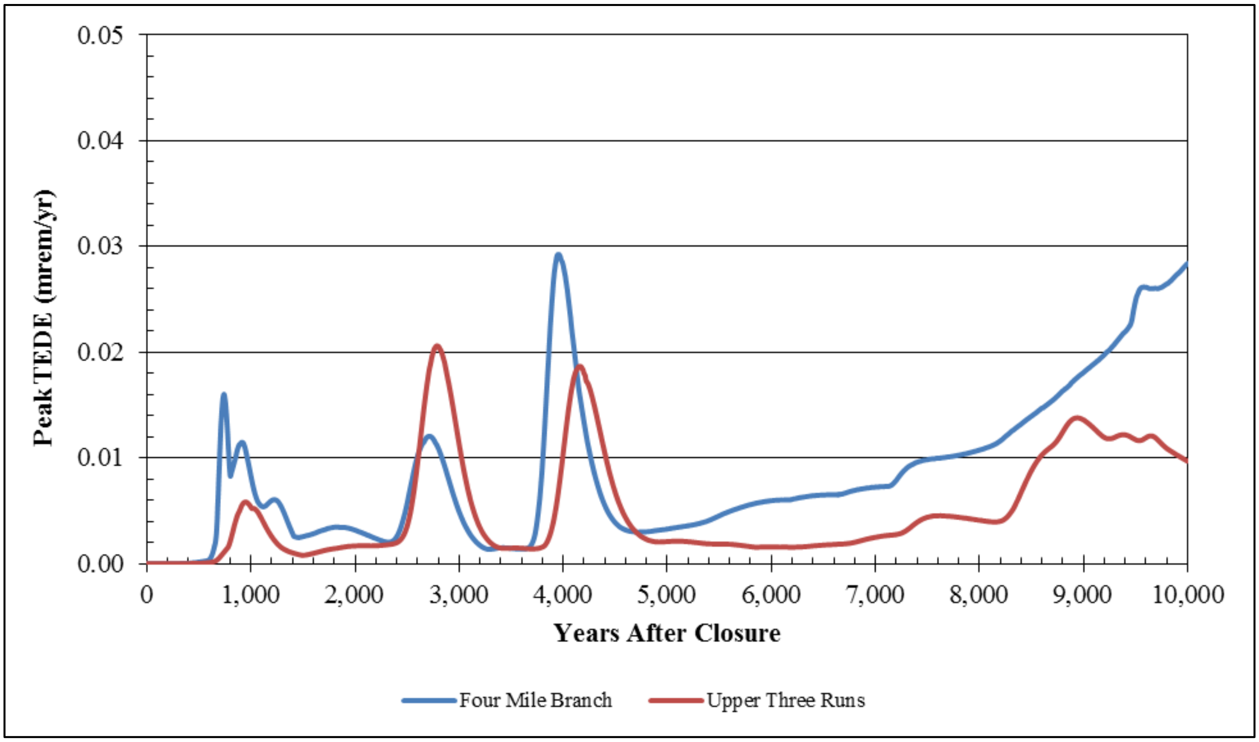
Figure 5.0-1: MOP Peak Groundwater Pathway TEDE at 100-Meter Assessment Point within 10,000 Years Showing the Tank 12H Contribution



[SRR-CWDA-2014-00106]

The HTF PA provided groundwater concentrations and radiological peak doses at different assessment points that can be utilized in the subsequent decision documents. The HTF PA provided groundwater radionuclide concentrations at 100 meters, and at the two seeplines downgradient from the HTF (Upper Three Runs [UTR] seepline approximately 2,400 meters northwest and Fourmile Branch [FMB] seepline approximately 1,200 meters southwest). These locations are shown in Figures 5.2-5 and 5.2-6 of the HTF PA. The groundwater radionuclide and chemical concentrations are provided at different aquifer depths in the HTF groundwater modeling. The HTF PA also documents groundwater concentrations for various chemical contaminants. The Tank 16H SA assesses and documents the updated peak radionuclide and chemical concentrations at each of these same assessment locations reflecting the replacement of the HTF PA assigned inventories in the ICM with the Tank 16H final and Tank 12H forecasted inventories . Figure 5.0-2 shows that the MOP TEDE peak at the seeplines are approximately two orders of magnitude less than the TEDE at the 100-meter assessment point within 10,000 years. As described in Section 5.1, the more plausible location for groundwater exposure to a future MOP would be at the UTR or FMB seeplines.

Figure 5.0-2: HTF Base Case MOP Peak TEDE at the UTR and FMB Seeplines within 10,000 Years



[SRR-CWDA-2014-00106]

The peak groundwater concentrations calculated in the HTF PA and Tank 16H SA are associated with specific locations and times. Since multiple inventory sources are modeled, there is significant temporal and spatial complexity inherent in the modeling system. Removal of any one inventory source term may reduce the concentrations (including the peak concentration, where applicable) associated with that source term, but the overall HTF peak concentrations will not necessarily be reduced by a corresponding amount. The overall HTF concentrations will merely shift to a different location and time. As a result, completely removing the entire inventory from a single source would not necessarily result in an equivalent corresponding concentration reduction, since another waste source (e.g., one of the other waste tanks) would then replace the affected source as the primary contributor to the peak concentration. For some contaminants there may not be a significant peak concentration decrease from the 100-meter assessment point to the seepline because the seepline peak concentration is influenced by multiple inventory sources rather than a single source. As presented in the HTF PA (Sections 4.2.2 and 4.4.4.1), the HTF is located over a groundwater divide between UTR and FMB, and contaminants can eventually discharge to both streams, depending on the contaminant origination point.

HTF General Closure Plan Performance Objectives

The *Industrial Wastewater General Closure Plan for H-Area Waste Tank Systems* (SRR-CWDA-2011-00022) performance objectives applied to groundwater concentrations for the HTF waste tank systems are:

- The SCDHEC *State Primary Drinking Water Regulation* for radionuclides (i.e., 4 mrem/year beta-gamma annual dose equivalent, 15 pCi/L total alpha concentration, and 5 pCi/L total Ra-228 + Ra-226) [SCDHEC R.61-58]
- The SCDHEC *State Primary Drinking Water Regulation* MCLs for nonradiological inorganic constituents [SCDHEC R.61-58]

These performance objectives are used only in the PA process to provide reasonable assurance that during the interim period from waste tank grouting to final HTF FFA corrective/remedial actions, it can be concluded that groundwater concentrations derived from residual contamination in the waste tanks and ancillary structures will be within the performance objectives.

5.1 Tank 16H SA Modeling Results

The impacts from operationally closing Tank 12H were modeled using the forecasted Tank 12H inventory, final Tank 16H inventory, and assigned inventory projections for the waste tanks that have not completed waste removal. The Tank 16H SA constituent modeling results are presented and compared in Table 5.1-1 to the SCDHEC drinking water standards. [SCDHEC R.61-58] The results are provided at the UTR and FMB seeplines as discussed in Section 5.4 of *Industrial Wastewater General Closure Plan for H-Area Waste Tank Systems,* and at 100 meters from the HTF boundary. [SRR-CWDA-2011-00022] As described in Section 5.4 of the HTF GCP:

- *SRS will be owned and controlled by the Federal government in perpetuity,*
- *The property will be used only for industrial purposes,*
- *Site boundaries will remain unchanged, and*
- *Residential use will not be allowed on-site. [SRR-CWDA-2010-00128]*

> *Therefore, a scenario in which a future hypothetical MOP establishes a residence directly on the HTF and obtains drinking water from the water table below is extremely unlikely. A more plausible, although still highly unlikely, location for the future MOP to be exposed to the groundwater below the HTF would be at the UTR seepline or the Fourmile Branch seepline…*

In all cases, the modeling results demonstrate reasonable assurance that the respective peak concentrations or peak doses remain well below the state drinking water standard value during the 1,000-year DOE compliance period following closure of all HTF sources. The results presented in this section are from the Tank 16H SA Base Case modeling and represent the best estimate or most probable and defensible scenario for modeling. For some constituents listed in Table 5.1-1 (e.g., Al, Sb, and Cr), the predicted concentrations are higher at the FMB seepline than at the 100-meter location due to the cumulative effect of multiple inventory sources and the complex HTF hydrogeology.

Table 5.1-1: Tank 16H SA Modeling Results Within 1,000 Years Following HTF Closure

Constituent	Units	MCL[a]	Peak Groundwater Concentrations		
			100 meters	FMB Seepline	UTR Seepline
Nonradiological					
Aluminum (Al)	µg/L	100	1.8E-27	1.2E-26	2.1E-31
Antimony (Sb)	µg/L	6	3.2E-33	1.5E-31	1.4E-36
Arsenic (As)	µg/L	10	4.3E-17	1.9E-19	4.2E-23
Barium (Ba)	µg/L	2,000	1.4E-04	1.2E-10	2.1E-12
Boron (B)	µg/L	NA	5.3E+01	7.1E-01	4.4E-01
Cadmium (Cd)	µg/L	5	4.4E-04	1.4E-10	2.4E-12
Chloride (Cl)	µg/L	250,000	2.6E-01	2.1E-02	3.8E-03
Chromium[b] (Cr)	µg/L	100	8.3E-28	2.5E-27	5.8E-32
Cobalt (Co)	µg/L	NA	7.3E-11	1.4E-15	7.1E-19
Copper (Cu)	µg/L	1,300	7.2E-11	2.8E-15	1.2E-18
Fluoride (F)	µg/L	4,000	1.7E-01	1.1E-02	3.9E-03
Iodine (I)	µg/L	NA	3.7E-03	3.1E-04	5.9E-05
Iron (Fe)	µg/L	300	1.3E-16	3.7E-18	4.1E-22
Lead (Pb)	µg/L	15	3.3E-31	8.0E-30	9.2E-35
Manganese (Mn)	µg/L	50	1.3E-03	2.3E-09	4.1E-11
Mercury (Hg)	µg/L	2	3.0E-25	4.8E-25	1.4E-29
Molybdenum (Mo)	µg/L	NA	5.8E-27	1.8E-26	4.1E-31
Nickel (Ni)	µg/L	100	5.0E-02	5.7E-07	4.2E-08
$NO_2 + NO_3$ (as N)	µg/L	10,000	1.2E+01	8.1E-01	2.4E-01
Phosphate (PO_4)	µg/L	NA	1.3E+01	1.9E-01	1.2E-01
Selenium (Se)	µg/L	50	8.5E-30	2.6E-29	6.0E-34
Silver (Ag)	µg/L	100	1.6E-03	6.1E-10	1.1E-10
Strontium (Sr)	µg/L	NA	2.8E-03	1.2E-06	2.6E-08
Sulfate (SO_4)	µg/L	250,000	1.2E+02	2.1E+00	1.5E+00
Uranium (U)	µg/L	30	1.6E-20	1.5E-21	1.1E-25
Zinc (Zn)	µg/L	5,000	1.5E-04	4.7E-11	7.9E-13
Radiological					
Beta-gamma dose[c]	mrem/yr	4	4.0E-01	3.3E-02	1.2E-02
Alpha concentration	pCi/L	15	2.5E-01	4.0E-03	1.3E-04
Total Ra-226 + Ra-228	pCi/L	5	8.3E-09	8.0E-14	6.0E-17

NA Not Applicable

[a] SCDHEC R.61-58

[b] Total chromium (chromium III and VI)

[c] 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]

In addition, a 10,000-year qualitative evaluation was performed to evaluate system performance and future potential risks associated with HTF closure activities. This 10,000-year evaluation indicated that the 100 meter results for the manganese (Mn) concentration and beta-gamma annual dose equivalent would be above the state drinking water standard. Mn was the only non-radiological contaminant migration constituent of concern (CMCOC) identified with a modeled peak concentration above the state drinking water standard within 10,000 years. The modeled Mn concentration of 250 µg/L is above the 50 µg/L state drinking water standard at the 100-meter assessment point, but is below the state drinking water standard at both seeplines (Table 5.1-2). Similarly the 11 mrem/year modeled beta-gamma effective dose equivalent (EDE) at 10,000 years is also above the 4 mrem/year annual dose equivalent state drinking water standard at the 100-meter assessment point, but is below the state drinking water standard at both seeplines (Table 5.1-2).

The modeled beta-gamma concentration at 100 meters within 10,000 years is above the 4 mrem/year state annual dose equivalent drinking water standard primarily due to I-129, which constitutes approximately 75% of the calculated 11 mrem peak. The modeling assumptions inherent in the I-129 contribution to the beta-gamma peak (e.g., low distribution coefficients allowing fast contaminant transport) are such that the beta-gamma peak is not expected to move forward in time (i.e., into the 1,000-year DOE compliance period). [SRR-CWDA-2014-00106, Appendix B]

The Mn and beta-gamma results are discussed in Section 5.1.1.

To determine the peak alpha concentration, within 10,000 years, the sum of the concentrations of alpha-emitting isotopes, with the exception of uranium and radon, is determined for each year. In the Tank 16H SA, the modeled peak alpha concentration in the groundwater at the 100-meter assessment point occurs approximately 10,000 years following closure of the HTF. The primary contributors are Ra-226 and Np-237. The modeled peak total radium concentration occurs approximately 10,000 years following closure of the HTF. [SRR-CWDA-2014-00106, Appendix B] The modeled peak alpha and total radium concentrations are below the state drinking water standards at both seeplines and at the 100-meter assessment point.

The peak beta-gamma total body or internal organ dose is calculated using the most current water ingestion 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 equivalents to the total body or to any organ is calculated. This total body or internal organ dose equivalent is calculated on the basis of two (2) liters per day water intake, and is provided in the Tank 16H SA. [SRR-CWDA-2014-00106]

For the purpose of the 1,000-year DOE compliance period, the peak beta-gamma annual dose equivalent at the 100-meter assessment point and at the seeplines is conservatively calculated by adding the peaks of all contributors, regardless of when the peak occurs. For both the 100-meter assessment point and the seepline evaluations, the contributing peak sources are the ancillary structures and waste tanks modeled with initially failed liners (Tanks 12H, 14H, 15H, and 16H) since this peak dose occurs prior to the time associated with waste tank liner degradation for all other HTF waste tanks in the Base Case modeling. [SRR-CWDA-2014-00106, Appendix B]

Table 5.1-2: Tank 16H SA Modeling Results Within 10,000 Years Following HTF Closure

Constituent	Units	MCL[a]	Peak Groundwater Concentrations		
			100 meters	FMB Seepline	UTR Seepline
Nonradiological					
Aluminum (Al)	μg/L	100	1.3E-11	2.4E-15	7.3E-19
Antimony (Sb)	μg/L	6	4.7E-18	5.9E-19	8.1E-24
Arsenic (As)	μg/L	10	1.9E-04	7.5E-07	3.3E-08
Barium (Ba)	μg/L	2,000	1.8E+00	4.4E-02	7.5E-03
Boron (B)	μg/L	NA	5.3E+01	7.1E-01	4.4E-01
Cadmium (Cd)	μg/L	5	5.1E-01	1.0E-02	1.6E-03
Chloride (Cl)	μg/L	250,000	1.5E+02	2.6E+00	6.6E-01
Chromium[b] (Cr)	μg/L	100	2.8E-11	1.7E-13	2.1E-18
Cobalt (Co)	μg/L	NA	1.0E-02	5.4E-06	4.1E-07
Copper (Cu)	μg/L	1,300	4.6E-02	7.1E-05	6.9E-06
Fluoride (F)	μg/L	4,000	5.2E+01	1.2E+00	3.4E-01
Iodine (I)	μg/L	NA	1.0E+00	2.2E-02	4.6E-03
Iron (Fe)	μg/L	300	5.1E-02	2.8E-06	3.5E-08
Lead (Pb)	μg/L	15	4.0E-16	4.4E-17	4.9E-22
Manganese (Mn)	μg/L	50	2.5E+02[c]	1.6E+00	1.3E+00
Mercury (Hg)	μg/L	2	6.7E-09	2.6E-12	4.4E-17
Molybdenum (Mo)	μg/L	NA	1.0E-10	2.3E-14	1.1E-18
Nickel (Ni)	μg/L	100	3.9E-01	1.2E-02	2.6E-03
NO_2 + NO_3 (as N)	μg/L	10,000	4.5E+03	9.7E+01	3.1E+01
Phosphate (PO_4)	μg/L	NA	4.5E+01	8.5E-01	2.0E-01
Selenium (Se)	μg/L	50	1.5E-13	9.7E-18	1.8E-21
Silver (Ag)	μg/L	100	3.8E-01	7.6E-03	2.2E-03
Strontium (Sr)	μg/L	NA	2.3E+00	4.4E-02	9.9E-03
Sulfate (SO_4)	μg/L	250,000	1.2E+02	2.1E+00	1.5E+00
Uranium (U)	μg/L	30	1.1E-04	3.8E-10	3.1E-13
Zinc (Zn)	μg/L	5,000	2.9E+00	5.2E-02	6.0E-03
Radiological					
Beta-gamma dose[d]	mrem/yr	4	1.1E+01[c]	9.5E-02	6.4E-02
Alpha concentration	pCi/L	15	4.8E+00	6.5E-02	1.1E-02
Total Ra-226 + Ra-228	pCi/L	5	3.3E+00	2.4E-02	2.9E-04

[a] SCDHEC R.61-58

[b] Total chromium (chromium III and VI)

[c] Additional discussion is presented in Section 5.1.1.

[d] 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]

At the 100-meter assessment point, the primary contributor during the 1,000-year DOE compliance period is Tc-99 with the peak EDE occurring approximately 780 years following HTF closure. At the FMB seepline within the 1,000-year DOE compliance period, the primary contributor during the 1,000-year time period is Tc-99. The Tc-99 peak occurs approximately 740 years following HTF closure. The UTR seepline results are even lower.

The state drinking water standards represent the allowable dose or MCLs from drinking water directly from a free-flowing tap (e.g., kitchen sink faucet). In developing the drinking water standards, the following must be considered:

> *(a) incremental costs and benefits associated with a range of MCL values, (b) health effects to the general population and sensitive sub-populations, and (c) any increased health risk to the general population that may occur as a result of the new MCL. EPA may adjust the MCL for particular class or group of systems to a level that "maximizes health risk reduction benefits at a cost that is justified by the benefits."* [EPA_MCL_11-2012]

In the establishment of the state drinking water standards, the associated costs and benefits were considered. Comprehensive modeling in the Tank 16H SA, including uncertainty and sensitivity analyses, has demonstrated reasonable assurance that during the next 1,000 years following HTF closure, groundwater concentrations derived from residual contamination in the waste tanks and ancillary structures will be less than the state drinking water standards. Therefore, it may be concluded that there is reasonable assurance that, at the time of final FFA corrective/remedial actions for the HTF, groundwater concentrations will be below the state drinking water standards.

5.1.1 **Groundwater Concentration Discussion**

As shown in Table 5.1-2, within the 10,000-year time period following HTF closure, no constituents modeled are above the state drinking water standards at the UTR and FMB seeplines. Table 5.1-2 also presents the 100-meter modeling results within the 10,000-year time period following HTF closure. Within this 10,000-year time period following HTF closure, two constituents are above the state drinking water standards at the 100-meter assessment point (Table 5.1-2). The 250 µg/L modeled Mn peak, approximately 7,300 years following HTF closure, is above the state drinking water standard due to a change in the forecasted inventory for Tank 12H from the inventory modeled in the HTF PA. Tank 16H is not the primary contributor to the groundwater Mn concentration. As final characterization data are not yet available for Tank 12H residuals, the Tank 12H forecasted inventory was increased to account for uncertainties in residual Mn mass. As a result, the Mn inventory was increased approximately six times the value used in the HTF PA as described in the *H-Tank Farm Closure Inventory for use in Performance Assessment Modeling* (SRR-CWDA-2010-00023, Rev. 4). The final characterization of the Tank 12H residuals will be used in the Tank 12H SA and Tank 12H CM Addendum supporting operational closure of Tank 12H. The 50 µg/L Mn MCL is a secondary state drinking water standard for aesthetic or nuisance effects (above the MCL, the noticeable effects are black to brown water color, black staining on surfaces, and a bitter metallic taste). Mn is not a primary drinking water standard established for potential human health effects.

Similarly, the 11 mrem/year modeled beta-gamma EDE at 100 meters, approximately 2,600 years following HTF closure, is above the 4 mrem/year annual dose equivalent state drinking water standard due to a change in the forecasted inventory for Tank 12H from the inventory modeled in the HTF PA. The peak is driven by the contribution from I-129 which constitutes the majority (approximately 75%) of the beta-gamma EDE. As final characterization data are not yet available for Tank 12H residuals, the Tank 12H forecasted inventory was increased to account for uncertainties in residual I-129 inventory. As a result the I-129 inventory was increased by approximately 90 times the value used in the HTF PA as described in the *H-Tank Farm Closure Inventory for use in Performance Assessment Modeling* (SRR-CWDA-2010-00023, Rev. 4). The final characterization of the Tank 12H residuals will be used in the Tank 12H SA and Tank 12H CM Addendum supporting operational closure of Tank 12H to reflect the actual risk associated with I-129.

5.2 Assessment Evaluation

As described in this section, there is reasonable assurance that the groundwater concentrations derived from residual contamination in the HTF tanks and ancillary structures will be within the state drinking water standards during the next 1,000 years following HTF closure, based on the groundwater modeling performed within the Tank 16H SA. 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.

5.3 Tank 12H SA and Preliminary Investigative Modeling

As part of the Tank 12H RFS process, the final residual material inventory will be determined for Tank 12H and compared with the forecasted Tank 12H inventory that was developed for the Tank 16H SA Base Case modeling to find any potential variations. Additionally, investigative modeling runs will have been performed in advance of the Tank 12H final residual material inventory determination to examine potential impacts that certain constituents expected to be present in Tank 12H may have on the HTF groundwater peak TEDE. The results of the evaluation will be documented in a Tank 12H SA. As discussed in Section 4.0, the final Tank 12H inventory determination and the applicable results from the Tank 12H SA will be documented in an addendum to this CM.

6.0 ASSESSMENT OF THE IMPACT OF DEPLOYING ADDITIONAL REMOVAL TECHNOLOGY

This section documents an evaluation to determine if it is useful (e.g., that the potential benefits associated with further waste removal efforts outweigh the costs, such as monetary costs, delays in higher risk reducing activities, or occupational exposure of site workers to hazardous or potentially hazardous materials including radioactive materials) to develop and deploy another cleaning technology, assuming such a technology could be identified and safely deployed. This cost-benefit analysis considers a broad range of costs including resultant schedule impacts to other on-going cleaning activities and waste disposition activities, and also the current state of waste removal capabilities and technologies. As described below, the analysis shows that removing additional residual material from Tank 12H does not justify the costs of implementation or the impacts to on-going and future risk-reduction activities associated with waste removal and stabilization of other SRS waste tanks.

As described in Section 3.0, bulk waste removal and heel removal were performed in the Tank 12H primary tank between 2008 and 2013 during a series of campaigns using technologies categorized as either MSR or CSR. MSR campaigns utilized SLPs in a methodology which involved adding supernate or water to the tank, mixing the tank contents, and transferring the slurried sludge out of the tank in a batch process. A total of ten MSR campaigns (MSR-I) were performed as part of bulk waste removal. To initiate heel removal, an additional two MSR campaigns (MSR-II) were performed until sludge removal reached a point of diminished effectiveness. At the completion of MSR-I and MSR-II, the remaining sludge heel was difficult to suspend due to its rheological properties (i.e., higher yield stress). It also had a high concentration of aluminum compounds.

Following MSR-II, LTAD (CSR-I), which used caustic at an elevated temperature to dissolve aluminum compounds, was implemented. Operation of the SLPs was used to elevate the waste temperature. LTAD had been deployed at SRS to support sludge batch preparation, however, this was the first time that LTAD had been used in the heel removal process at SRS. In addition to dissolving approximately 57% of the aluminum from the Tank 12H sludge heel, LTAD also beneficially impacted sludge rheology by making the remaining sludge heel easier to suspend. LTAD was then followed by an additional five MSR campaigns (MSR-III) in preparation for BOAC. Due to the improved rheological properties of the sludge heel, when compared to sludge properties at the conclusion of MSR-II, MSR-III was successful in removing additional heel material. The final attempt at heel removal (CSR-II) employed BOA and operation of SLPs in Tank 12H, and reduced the residual heel to an estimated volume of less than 2,000 gallons. [SRR-CWDA-2013-00125] The BOAC technology was implemented, per the BOA flowsheet developed taking into consideration lessons learned from previous heel removal efforts on other waste tanks, to maximize removal of residual solids and minimize precipitation of oxalates. As discussed in Section 4.0, the final residual material volume determination, which is performed after the completion of residual sampling, will be discussed in detail in the Tank 12H CM addendum.

A total of 17 MSR campaigns and four CSR campaigns (one LTAD and three BOAC) were performed in Tank 12H. These campaigns were successful in removing over 99% of the solids (203,250 gallons reduced to less than 2,000 gallons).

As described in Section 4.1, the Tank 12H annulus contains less than 30 gallons of residual material introduced by leak sites through the primary tank wall. This amount of residual material is considered insignificant compared to the volume of residual material in the primary tank. Minimal benefit would result from annulus cleaning; therefore, a cleaning evaluation to explore options for annulus cleaning was not performed.

6.1 Analysis of Potential Cleaning Technologies

DOE has developed a robust process to assess the technical readiness of new technologies as described in DOE Guide 413.3-4A, *U.S. Department of Energy Technology Readiness Assessment Guide*. The process evaluates technology maturity using the Technology Readiness Level Scale that was pioneered by the National Aeronautics and Space Administration in the 1980s. It is through this process that DOE is able to validate that technologies have reached a level of maturity, ensuring a high probability of success before they are fully funded and deployed. As required by the HTF GCP, DOE continues to provide an annual technology briefing to SCDHEC. The most recent review is provided in the *Annual SCDHEC Technology Briefing* given in April 2014. [SRR-LWE-2014-00055]

There are three categories of cleaning technologies that can be deployed for additional cleaning in Tank 12H. These include mechanical removal, chemical removal, and vacuum technologies. The following subsections describe the available technologies and their viability for removing additional residual material from Tank 12H.

6.1.1 Mechanical Cleaning Technologies

As described in detail in Section 3.0 and as summarized above, up to four SLPs were used to provide mechanical mixing for 17 MSR and four CSR campaigns to remove over 99% of sludge solids from Tank 12H. At the completion of BOAC, no new optimized strategy had been identified for additional mechanical removal utilizing SLPs. The beneficial impact of replacing the SLPs with four SMPs in Tank 12H was discussed. SMPs, which have a higher effective cleaning radius than SLPs, had previously been used to remove sludge solids from Tanks 5F and 6F. However, the addition of four SMPs was estimated to cost greater than $5 million for disassembly, removal, and installation of the equipment alone. [SRR-CWDA-2013-00125] A formal cost estimate for performing additional MSR campaigns using SMPs (e.g., testing, operations, maintenance) was not generated, but the costs would have increased even further. In addition to the financial costs associated with installation of four SMPs, the collective dose to site workers, based on actual field installation work was expected to be approximately 100 to 200 mrem for each SMP installation (i.e., 400 to 800 mrem totals for four SMPs). The activities involved with opening tank risers and removing/installing equipment also involve the additional risk of potentially contaminating the work area. Remediation of a contaminated area would only add to the financial costs and worker exposure to clean-up the contamination. [10-FTF-139, 10-FTF-187, 10-FTF-198]

Deploying additional MSR campaigns using four SMPs would have an adverse impact on the already critical tank space in the Liquid Waste System. By tying up common infrastructure including transfer lines and diversion boxes additional MSR in Tank 12H would hinder waste removal activities in the remaining Type I and II tanks in HTF. For example, Tank 15H BWRE will be transferred via Tank 13H to Tank 51H. The majority of the transfers associated with additional MSR campaigns from Tank 12H would be sent to Tank 51H, the sole tank for preparation, qualification, and treatment of sludge waste at DWPF. The overall integration of waste transfers and equipment usage is a closely monitored process to maximize efficient use of all resources associated with risk reduction activities in HTF.

As described in the Liquid Waste System Plan, it is important to ensure that a continued sludge feed to DWPF be maintained. Without qualified sludge feed, DWPF would have to be shut down and sludge vitrification into canisters would cease. Competing processes and priorities must be considered when decisions are made involving the Liquid Waste System, which is integral to supporting waste removal, treatment, and processing activities to achieve tank closure. [SRR-LWP-2009-00001]

6.1.2 **Chemical Cleaning Technologies**

Two different chemical cleaning technologies were deployed in Tank 12H during heel removal. First, based on information obtained from sludge samples taken to improve sludge suspension in early MSR campaigns, LTAD emerged as an attractive technology for removing sludge solids from Tank 12H. In addition to dissolving aluminum compounds in the sludge heel, LTAD also lowered the yield stress of the remaining sludge making it easier to suspend with the SLPs. Though this technology was first identified in the 1980s as part of the original sludge batch washing process as a means of limiting aluminum compounds reaching DWPF, it had never previously been used in-situ in old-style waste tanks as a means to remove sludge heels. More detail on LTAD can be found in Section 3.4.2.

After the completion of some additional MSR campaigns post-LTAD, BOA was implemented. BOA represents the most mature chemical cleaning technology that has been successfully demonstrated at the SRS. BOA was successfully deployed as a chemical heel removal method in Tanks 5F and 6F in 2008 and 2009, respectively, and in Tank 12H in 2013 as described in Section 3.4.4. In each waste tank, at the completion of BOA, the majority of the waste tank floor was left with a relatively thin residual layer coupled with some small mounds of material. As described in Section 3.4.4, lessons learned from previous BOA campaigns were incorporated to maximize effectiveness in Tank 12H. Additionally, the safety analysis was updated to reflect corrosion testing completed on the HM sludge that typically exists in the HTF waste tanks. [SRR-CWDA-2014-00003] BOA was deployed until it reached the point of diminished effectiveness and was no longer a viable technology for residual removal. BOAC in Tank 12H (CSR-II campaigns 1 through 3) successfully reduced the residual material volume from 4,400 gallons to less than 2,000 gallons. Previously, multiple alternative evaluations of chemical waste removal technologies were evaluated to determine the best option for additional heel removal from SRS waste tanks. The evaluations identified potential chemical methods, along with other technologies, for additional heel removal. However, of the chemical methods, only BOA was identified as a potentially viable alternative. The remaining chemical methods were eliminated because they were not as effective as BOAC or due to technical maturity. [SRR-CWDA-2014-00003]

Chemical cleaning with BOA was identified as the only current potentially viable chemical cleaning technology for additional heel removal. However, BOA was previously deployed and had reached the point of diminished effectiveness; therefore, alternative flowsheets for deploying the BOA mixtures would be required. BOA supplemented with another reagent (potentially nitric acid or sulfuric acid) has been considered for future research. Deployment of BOA or supplemental acids mixed with traditional BOA solutions for additional heel removal would require additional testing to determine if alternate BOA flowsheets would be effective. Extensive analyses and safety evaluations would be required prior to consideration of using new BOA mixtures. [SRR-CWDA-2014-00003] The impact of deploying another series of BOAC campaigns in Tank 12H is unknown but the cost associated with developing and deploying a new BOAC strategy is expected to be greater than $2 million for costs associated with procurement and installation of the equipment alone. [SRR-CWDA-2010-00157] The full financial cost of developing, testing, and deploying an alternate chemical cleaning flowsheet was not formally estimated, but it would have increased the costs to even greater than $2 million. In addition to the financial costs associated with developing and deploying an alternate chemical cleaning flowsheet, additional dose to site workers would have been expected. Without knowing what a new flowsheet would entail, estimated worker dose is difficult to quantify. If no new equipment was required, additional dose to workers would have been minimal. However, if additional equipment (e.g., new downcomers, additional SMP) was required then workers' doses would have been expected to be similar to those associated with one SMP installation (i.e., 100 to 200 mrem) or even higher. In addition, the activities involved with opening up tank risers and removing/installing equipment, as well as the addition of chemicals (e.g., BOA) to the tanks, always comes with the additional risk of potentially contaminating the work area and requiring additional financial costs and worker exposure to clean-up the contamination. The oxalates associated with BOA are also anticipated to create tank farm evaporator foaming and scaling problems that would affect the rate at which tank space is recovered through evaporation. [LWO-SPT-2008-00033]

Additional chemical cleaning campaigns would have had the same adverse impact on the Liquid Waste System as the previously discussed impacts of additional mechanical cleaning campaigns, as well as additional potential negative impacts resulting from the formation of oxalates. Potential impacts resulting from the additional waste volume produced or additional oxalates produced would include:

- Additional wash cycles to the DWPF sludge batch feed preparation to remove oxalates from the DWPF feed
- An increased likelihood of feed breaks to the DWPF
- Potentially significant increase in volumes of feed to salt waste treatment processes that could impact salt waste processing and therefore impact other tank waste removal risk reduction activities
- Possible extension of the operating life requirements with the increasing risks associated with aging equipment and infrastructure for the entire Liquid Waste System [SRR-STI-2010-00015]

The final sampling and analysis of Tank 12H residuals and the subsequent analysis provided in the Tank 12H SA (utilizing the final inventory) is not expected to reveal any new information that brings into question the costs or benefits associated with additional CSR campaigns discussed above. In addition, no new chemical cleaning technologies are technically mature enough for deployment in the SRS waste tanks. [SRR-LWE-2014-00055]

6.1.3 Vacuum Cleaning Technology

The proven Mantis technology that was deployed in Tanks 18F and 19F cannot be deployed in Tank 12H due to in-tank obstructions such as cooling coils and tank support columns. At the completion of the campaigns in Tank 12H, technology development for a smaller robotic platform with vacuum capability had not reached a technical maturity level to support deployment in a Type I tank, and the effectiveness of this type of technology in a Type I tank remains uncertain. These small platforms have limited applicability due to mobility around and over in-tank obstacles, if deployed with the tether management systems that would be associated with a vacuum device. [SRR-LWE-2011-00107] Smaller robotic platforms have been utilized to perform sampling tasks within the waste tanks, as described in Section 4.0.

6.2 Predicted Dose Overview

As described in Section 5.0, the Tank 16H SA evaluated the impact of HTF closure actions based on the following ICM inputs:

- A forecasted residual inventory for Tank 12H
- The final residual inventory for Tank 16H
- Revised residual inventory assignments for remaining waste tanks and ancillary structures to reflect updated residual material inventory information [SRR-CWDA-2010-00023, Rev. 4]
- The same deterministic (PORFLOW) and probabilistic (GoldSim) conceptual models that were developed for the HTF PA (SRR-CWDA-2010-00128) with updated material distribution coefficients

The results of the Tank 16H SA using the forecasted Tank 12H inventory were compared to the results in the HTF PA to confirm that this updated information did not adversely impact the HTF PA results. The Tank 16H SA provides reasonable assurance that the groundwater contaminant concentrations derived from residual contamination in the waste tanks and ancillary structures following removal from service will be below the performance objectives. As discussed in Section 4.0, after obtaining Tank 12H sample analysis results, the Tank 12H final residual inventory will be determined and compared to the Tank 12H forecasted residual inventory through development of the Tank 12H SA. The results of the Tank 12H SA using the final residual inventory will be presented as an addendum to this CM.

DOE M 435.1-1 establishes a DOE compliance period of 1,000 years for quantitatively assessing whether there is reasonable assurance that performance objectives will be met. As discussed in Section 5.0 and shown in Table 5.1-1, with the updated HTF waste tank inventories, there is reasonable assurance that the projected peak groundwater concentrations at the assessment points will remain below the performance objectives for the initial 1,000 years after closure of HTF. The DOE has also evaluated beyond this 1,000-year time period (i.e., for 10,000 years) to qualitatively assess potential risk and further inform the conclusions regarding reasonable assurance within the 1,000-year DOE compliance period.

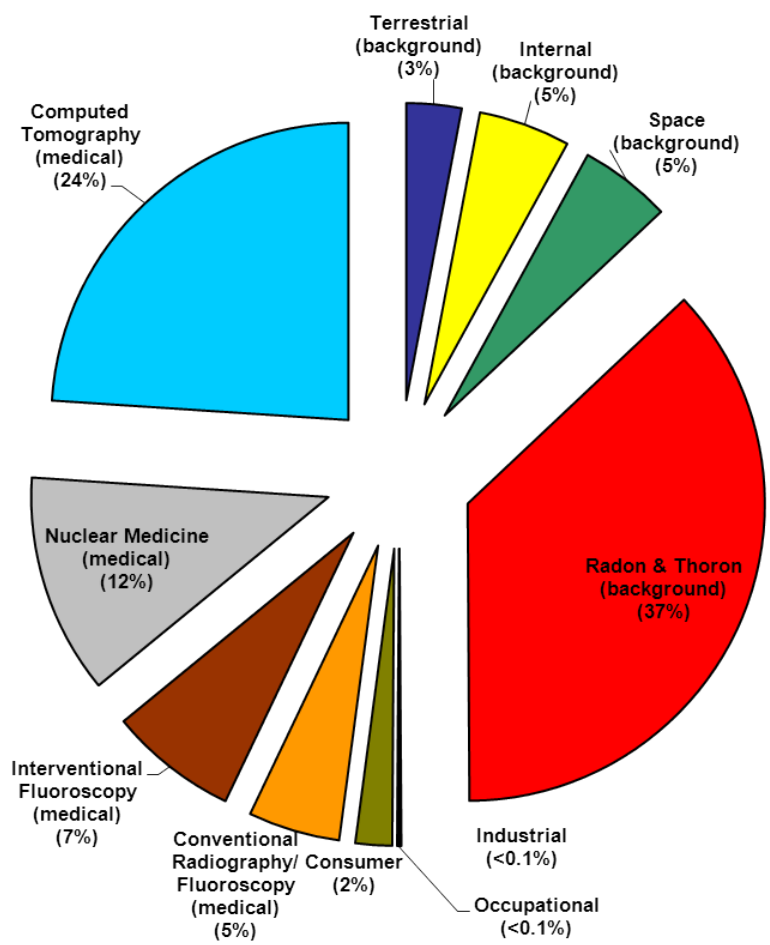
Although not prescribed by the HTF GCP, the peak all-pathways radiological dose impacts (TEDE) were evaluated in the Tank 16H SA. It showed that the peak TEDE to a MOP living 100 meters from the HTF boundary at any point in time for the initial 1,000 years following HTF closure is 0.2 mrem/year. In the initial 10,000-year period, the peak TEDE is approximately 4 mrem/year at the 100-meter assessment point. [SRR-CWDA-2014-00106] It should be noted that the peak TEDE cannot be directly compared to the 4 mrem/year gross beta-gamma state drinking water standard, nor to the value calculated for comparison purposes versus the gross beta-gamma standard shown in Table 5.1-1 (i.e., 0.4 mrem/year at 1,000 years). The state drinking water standard was derived to establish acceptable concentrations in drinking water.

The assumptions used to calculate the state drinking water standard differ from those used to calculate an all-pathways peak dose (TEDE). While the state drinking water standard only assesses hazards associated with drinking water, the all-pathways dose considers much broader resident scenarios involving drinking and showering with water from a contaminated well and also using the contaminated water to grow livestock and crops that are consumed by the hypothetical individual. The HTF PA Section 5.5.3 provides a detailed description of the exposure pathways associated with the all-pathways dose. [SRR-CWDA-2010-00128]

6.3 Radiation Exposure Perspective

All human beings are exposed to both naturally occurring and man-made sources of ionizing radiation. To put the estimated doses to a MOP living 100 meters from the closed HTF in perspective, a person living in the United States receives an annual radiation dose, on average, of approximately 620 mrem/year. Figure 6.2-1 provides a breakdown of this exposure.

Figure 6.2-1: Major Sources of Radiation Exposure Near SRS



The major sources of radiation exposure to an average MOP in the Central Savannah River Area are attributed to naturally occurring radiation (311 mrem/year) and medical exposure (300 mrem/year). This naturally occurring radiation is often referred to as natural background radiation and includes dose from background radon and its decay products (37%), cosmic radiation (5%), internal radionuclides occurring naturally in the body (5%), and natural radioactive material in the ground (3%). The dominant medical sources include dose from computed tomography (24%), nuclear medicine (12%), and radiography/fluoroscopy (12%). The remainder of the dose is from consumer products (2%), industrial/educational/research activities (0.1%), and occupational exposure (0.1%). [NCRP-160]

Using the final residual material inventory in Tank 16H, the forecasted residual material inventory in Tank 12H, and the assigned inventory projections for remaining HTF waste tanks and ancillary structures, the all-pathways HTF peak TEDE (i.e., the highest single year dose in the years following closure of HTF) is estimated to be 0.2 mrem within 1,000 years and 4 mrem within 10,000 years. [SRR-CWDA-2014-00106] These peak doses are approximately 0.1 and 1%, respectively, of the naturally occurring background radiation (311 mrem/year) in this area, and even less when considering all sources of radiation exposure to the average person living in the United States.

6.4 Assessment Conclusion

Based on this evaluation of technology capability, schedule and quantified cost/benefit analysis, deployment of additional waste removal technology in Tank 12H would not be practicable for the following reasons:

Technology Evaluation Summary

No new practicable technology has been identified that has reached a level of maturity for deployment to remove a significant additional concentration of constituents of concern from Tank 12H. The three broad categories of cleaning technologies (i.e., mechanical, chemical and vacuum) which have been used at SRS were evaluated for viability in removing additional waste.

- The only viable option for additional mechanical cleaning would be replacing the SLPs with SMPs. However, the removal of four SLPs followed by the installation and operation of four SMPs would require significant financial cost, schedule impacts, and impact to other on-going risk reduction activities. In addition, the effectiveness of four SMPs on additional solids removal is uncertain due to the small amount of residual solids (less than 2,000 gallons) remaining and the large number of in-tank obstructions (i.e., cooling coils).

- BOA cleaning, the current baseline chemical cleaning technology, was deployed in Tank 12H and reached the point of diminished effectiveness and was no longer a viable technology for residual removal. The use of alternate flowsheets involving oxalic acid in conjunction with supplemental acids would require development and testing to determine the capability of removing additional material and the potential impacts. No alternate chemical cleaning process (i.e., other than BOA) has reached a level of maturity for deployment in Tank 12H and the effectiveness of any alternative chemical cleaning process is uncertain.

- The proven Mantis technology that was deployed in Tanks 18F and 19F cannot be deployed in Tank 12H due to in-tank obstructions such as cooling coils and tank support columns. Current technology development for a smaller robotic platform with vacuum capability has not reached a technical maturity level to support deployment in Tank 12H and the effectiveness of this type of technology in a Type I tank is uncertain.

Cost/Benefit Analysis Summary

An evaluation of the costs and benefits of potential risk reduction from removing additional residual material from Tank 12H is summarized below.

- The financial costs associated with deployment of additional heel removal activities was estimated to be greater than $5 million for installation and operation of four SMP's and greater than $2 million for development and deployment of additional chemical cleaning campaigns. No viable vacuum technology was identified.
- The expected potential radiological dose to the workers to perform additional heel removal activities would be approximately 100 to 200 mrem for chemical cleaning and 400 to 800 mrem for mechanical cleaning with four SMPs.
- Deployment of additional heel removal technologies would have resulted in impacts to other risk reduction activities including waste removal activities associated with other Type I, II, and IV tanks and preparation of DWPF sludge batches.
- Without performing additional studies with actual field tests, the effectiveness of any additional heel removal technology cannot be accurately predicted.
- In the HTF PA Base Case model, further removal of the residuals in Tank 12H does not impact meeting the performance objectives within the 1,000-year DOE compliance period after HTF closure.

No new practicable technology for removing additional residual material from Tank 12H was identified in the technology evaluation, and without performing additional studies with actual field tests, the effectiveness of any additional heel removal technology cannot be accurately predicted. Nevertheless, even if a technology could be identified and deployed, the limited benefit associated with further removal of residuals from Tank 12H does not justify the associated additional costs including the resulting delays in other risk-reducing activities in the Liquid Waste System. Therefore, it may be concluded that further residual removal is not technically practicable from an engineering perspective.

As previously noted, upon obtaining Tank 12H sample analysis results, the Tank 12H final inventory and the results of the Tank 12H SA using the final inventory will be presented in a future addendum to this CM.

7.0 WASTE TANK SYSTEM ISOLATION PROCESS AND STABILIZATION STRATEGY

This section summarizes the planned waste tank system isolation process and subsequent stabilization strategy to be implemented on Tank 12H after waste removal is complete. In particular, the following attributes will be described.

- Waste tank system isolation process and final configuration of the waste tank system
- Description of structures and equipment that are part of this RFS activity including any equipment that will remain in Tank 12H at the time of RFS
- Stabilization strategy including type and characteristics of fill material (i.e., grout), as appropriate

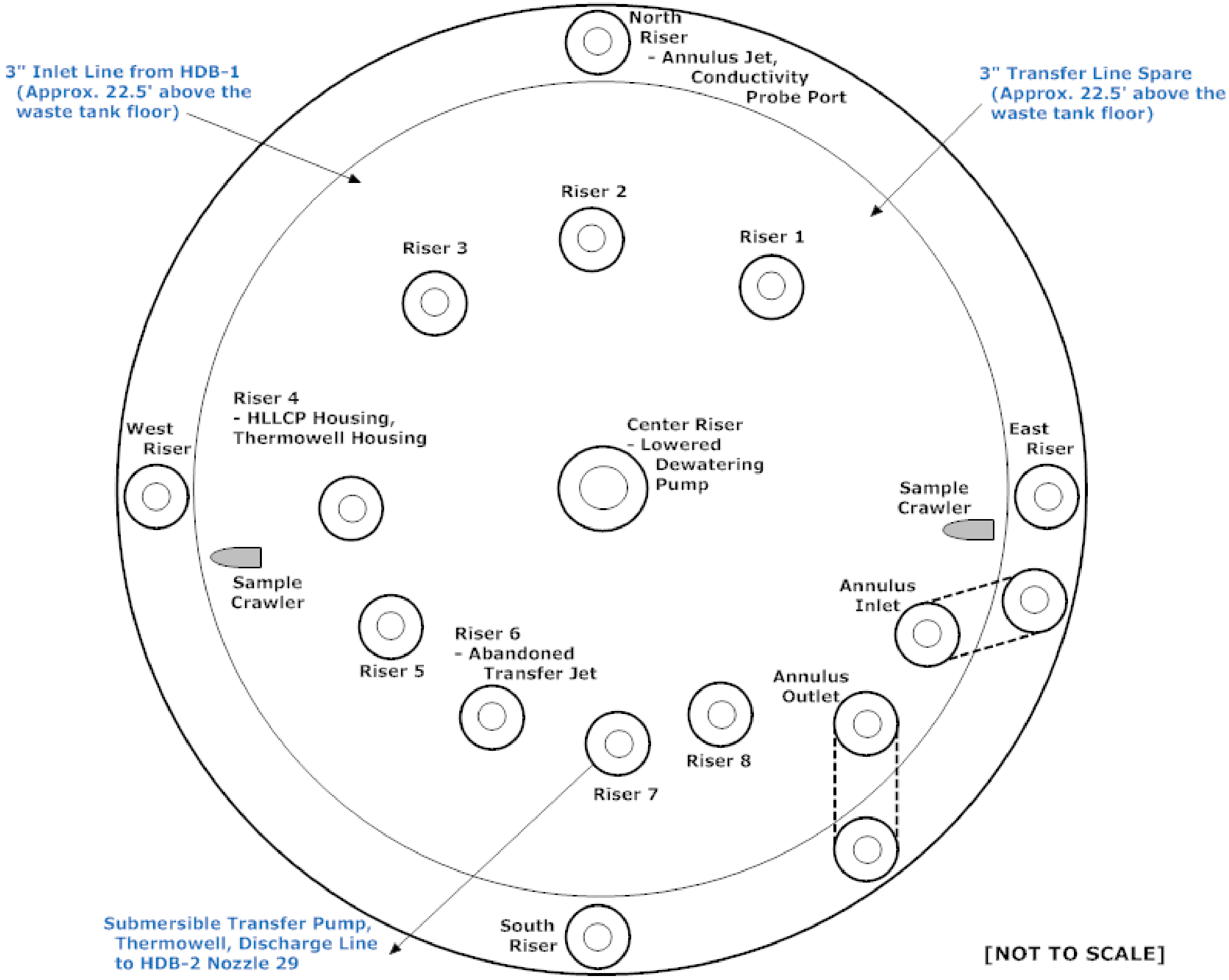
7.1 Waste Tank System Isolation Process

The isolation process for Tank 12H isolates the waste tank from the HTF Waste Transfer System (WTS) and the HTF support systems. Implementation of the process consists of identification and isolation of transfer lines, drain lines, water, air, and steam supply lines, ventilation lines, power and instrumentation lines, and all other penetrations into, or out of, the waste tank. Isolation of these systems will be performed at the electrical control rooms or at the field location for electrical services and instrumentation for mechanical systems. Isolation for mechanical systems will be at the system supply headers located away from the tank top. Where practical, accessible piping and conduit will be removed creating a physical break from the waste tank. Other pipes will be plugged or capped to isolate them from the HTF systems. Isolating all systems from the waste tank will render the waste tank closed to waste processing activities. [M-CTP-H-00003]

7.1.1 **Tank 12H System Isolation**

The three Tank 12H penetrations into the waste tank or tank risers, to be isolated during RFS, are shown on Figure 7.1-1 and described in Table 7.1-1. As Tank 12H is filled with grout, grout material will flow into the isolated waste tank, risers, and waste tank penetrations, thereby effectively sealing the abandoned transfer lines. This will eliminate the possibility of transferring waste into, or out of, the waste tank through the abandoned transfer lines. Though the grout will seal the abandoned transfer lines at the waste tank penetrations, there are no current plans to fill the abandoned HTF transfer lines exterior to the waste tank with grout. The waste transfer lines were modeled in the HTF PA with no grout and the results predicted compliance with the required performance objectives. [SRR-CWDA-2010-00128] Because any residual waste would be on the interior wall of the transfer lines and grouting would not significantly influence the leaching rate, there is no environmental benefit to grouting these small diameter transfer lines. In addition, there is no long-term subsidence issue requiring stabilization of the lines due to the small diameter of the transfer piping. Additional details on the isolation strategy for the Tank 12H systems from the HTF WTS and support systems can be found in the *Tank 12H Isolation Plan*. [M-CTP-H-00003] As new information is made available from field walkdowns and waste tank inspections, any necessary changes will be documented.

Figure 7.1-1: Tank 12H Riser Diagram



[SRR-LWE-2014-00147]

Table 7.1-1: Tank 12H Line Penetrations

Line Description	Size	Location
Spare transfer inlet line	3-inch line in concrete encasement	Located approximately 22.5 feet above the waste tank floor
Transfer line from HDB-1	3-inch line in concrete encasement	Located approximately 22.5 feet above the waste tank floor
Transfer line to HDB-2	3-inch line in 4-inch jacket	Located approximately 34 feet above the waste tank floor

[SRR-LWE-2014-00147]

7.2 Structures and Equipment Involved with RFS

Modifications to the top of Tank 12H will be made to accommodate waste tank grouting and riser capping activities. Risers or other waste tank penetrations extending above the grade level will not require capping if the grout level in the riser or penetration also extends above the grade level. In those risers or waste tank penetrations where bringing the grout level above the grade level is not achievable, a grout cap shall be placed greater than, or equal to, the height of the void. After external motors, piping, electrical, and instrumentation commodities have been removed from the riser, individual risers may be capped with bulk-fill grout, 5,000 psi concrete, or other suitable material. Each waste tank riser will be filled with grout from the top. [SRR-LWE-2014-00147] After all waste tanks and ancillary structures in the HTF have been removed from service, decisions on removal of external structures such as structural steel trusses, mechanical and electrical piping/conduit, instrumentation and power cables/wiring, raceways, motors, and any other remaining equipment from the waste tank top footprint will be addressed in conjunction with the final RCRA/CERCLA closure of the HTF Operable Unit.

Additional details on the isolation of the waste tank mechanical, electrical, equipment and piping systems from service are presented in the *Tank 12H Isolation Plan*. [M-CTP-H-00003] The isolation strategy will continue to be updated, as necessary, with new information made available from field walkdowns and tank inspections.

Several pieces of equipment used in supporting waste removal efforts and heel removal efforts from the tank will be entombed in place with grout as part of the RFS process. Equipment planned to be entombed in the grout in the Tank 12H primary and annulus is included in Tables 7.2-1 and 7.2-2, respectively. As new information is made available from field walkdowns and tank inspections, any necessary changes will be documented. Internal space in this equipment will be filled with grout to the extent practicable to minimize void space, as the waste tank is filled. [SRR-LWE-2014-00147]

Table 7.2-1: Equipment to Remain in Tank 12H Primary

Equipment	Grout Plan	Location(s)
Four spray wash chambers	Grout fill risers via hole drilled in spray wash chambers	Risers 1, 3, 5, and 8
High Liquid Level Conductivity Probe (HLLCP), HLLCP housing, thermowell, purge ventilation inlet, blanked heating and ventilation drain	Grout fill HLLCP and thermowell housing, entomb HLLCP and thermowell	Riser 4; HLLCP and thermowell on tank floor
Transfer jet	Grout fill transfer jet	Riser 6
Submersible transfer pump with caisson, thermowell	Grout fill transfer pump and thermowell, entomb caisson	Riser 7
Dewatering pump	Entomb pump	Center Riser; Modification to Center Riser to install ventilation outlet duct

[SRR-LWE-2014-00147]

Table 7.2-2: Equipment to Remain in Tank 12H Annulus

Equipment	Grout Plan	Location(s)
Annulus jet, HLLCP housing, HLLCP	Grout fill HLLCP housing and annulus jet, entomb HLLCP	North Riser; HLLCP on tank floor; Modification to North Riser to install ventilation outlet duct
Conductivity probe	Grout fill HLLCP housing, entomb HLLCP	South Riser; HLLCP on tank floor; Modification to South Riser to install ventilation outlet duct
Steel wall temperature element	Entomb temperature element	East Riser on tank floor
Sample crawler	Entomb sample crawler	East Region on tank floor
Sample crawler	Entomb sample crawler	West Region on tank floor

[SRR-LWE-2014-00147]

7.3 Stabilization Strategy

7.3.1 Waste Tank Grouting Selection

In May 2002, DOE issued an Environmental Impact Statement (EIS) on waste tank cleaning and stabilization alternatives. [DOE-EIS-0303] The DOE studied five alternatives:

- Empty, clean, and fill waste tank with grout
- Empty, clean, and fill waste tank with sand
- Empty, clean, and fill waste tank with saltstone
- Clean and remove waste tanks
- No action

The EIS concluded the Fill-with-Grout option was preferred. The DOE also issued a Record of Decision selecting the Fill-with-Grout alternative for SRS waste tank closure. [DOE-EIS-0303 ROD]

Evaluations described in the EIS showed the Fill-with-Grout alternative was the best approach to minimize human health and safety risks associated with closure of the waste tanks. [DOE-EIS-0303] This alternative offers several advantages over the other alternatives evaluated such as:

- Provides greater long-term stability of the waste tanks and their stabilized contaminants than the sand-fill approach;
- Provides for retaining radionuclides within the waste tanks by using reducing agents in the grout in a fashion that the sand-fill would not;
- Avoids the technical complexities and additional worker radiation exposure that the fill-with-saltstone approach would entail;
- Produces smaller impacts due to radiological contaminant transport than the sand- and saltstone-fill alternatives;

- Avoids the excessive personnel radiation exposure, and provides greater occupational safety impact that would be associated with the clean-and-remove alternative. [DOE-EIS-0303]

Cementitious materials are often used to stabilize radioactive wastes. Grout has been one of the most commonly used materials for solidifying and stabilizing radioactive wastes, and the technology is at a mature stage of development. [ISBN-10: 0-309-06431-7] The purpose of this stabilization is to maintain waste tank structure and minimize water infiltration over an extended period of time, thereby impeding the release of stabilized contaminants into the environment. The grout fill that will be used has reducing properties (i.e., low redox or Eh) which minimize the mobility of the chemicals after closure. All grout formulas are alkaline because grout is a cement-based material that naturally has a high pH. This alkalinity is compatible with the carbon steel waste tank construction material. Grout has a high compressive strength and low permeability, which enhances its ability to limit the migration of contaminants after closure. The grout formulas are also designed to promote flowability, thereby enabling a near level placement within the waste tank. [SRNL-STI-2011-00551, SRR-CWDA-2010-00128]

Grout is primarily a mixture of cement and water proportioned to produce a pourable consistency. Studies have focused on improving grout production and batching, grout flow, measurement of the effective diffusion coefficients in reducing fill grout, and measurement of hydraulic properties. [WSRC-STI-2007-00369, WSRC-STI-2007-00641]

Filling a cleaned waste tank with grout prevents the walls and ceiling from possible collapse thereby providing long-term stability. The grout fill also helps to reduce water intrusion into the waste tank over time. Reducing the amount of water entering a closed waste tank retards the migration of residual materials from the waste tank to the environment. Testing has demonstrated that the chemical and physical characteristics of the grout formula used at SRS retards the movement of chemical and radiological constituents. [WSRC-TR-97-0102]

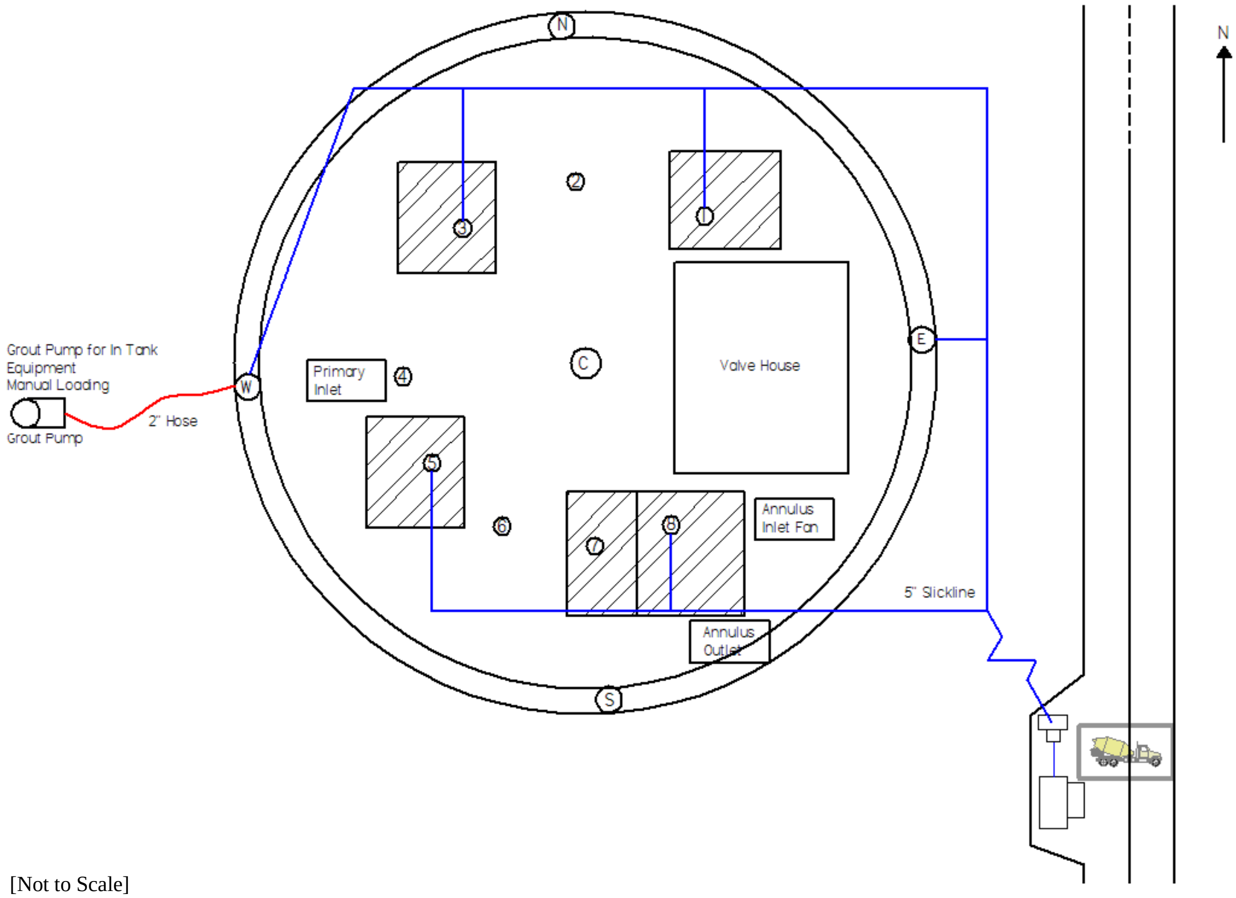
7.3.2 Waste Tank Grouting Plan

Grout will be supplied by an off-site vendor. The vendor will deliver the grout to HTF using unmodified concrete mixer trucks. The grout will be off-loaded to a hopper. Pumps will push the grout through commercial slicklines to the primary tank and annulus grouting risers. The slicklines will be configured to support the filling of one primary or annulus riser at a time. The primary tank and the annulus will be filled with grout in a sequence that will be protective of the wall structure. [SRR-LWE-2014-00147]

Reducing grout will be used to fill the entire Tank 12H primary and annulus tank volume, with the possible exception of the annulus ventilation duct, which may require an alternative grout mixture with more flowability (see Section 7.3.3). The reducing grout will flow and cover the remaining residual material. The ability of the grout to flow and cover the remaining residual material was successfully demonstrated during the grouting of Tanks 5F and 6F. However, internal waste tank obstructions and interferences in Tank 12H increase the risk of uneven grout distribution. To reduce this risk, the plan is to introduce bulk fill grout into the primary tank at multiple risers. If additional pour locations are required to cover the remaining residual materials, additional access points will be identified and installed to address the exact area requiring special effort. The location and number of risers to be used during grouting will be dependent on actual field conditions experienced. Figure

7.3-1 shows a typical grout equipment layout. [SRR-LWE-2014-00147] Figure 7.3-2 illustrates the typical grouted configuration for a Type I tank. [SRR-CWDA-2010-00128]

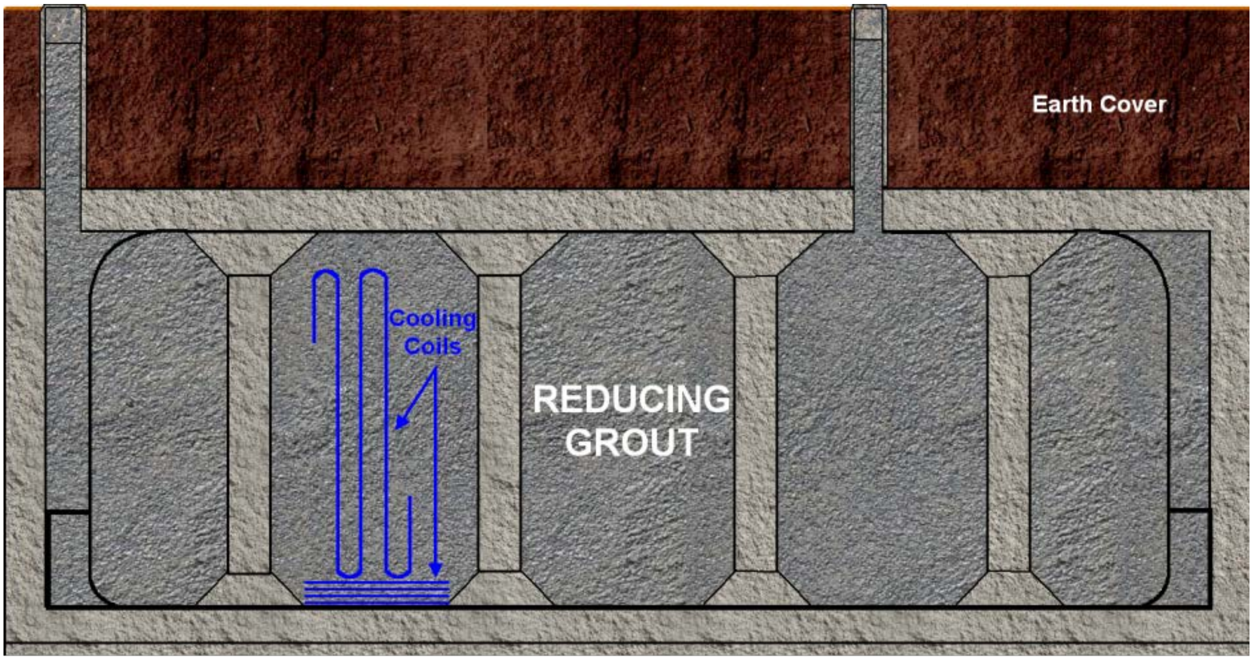
Figure 7.3-1: Tank 12H Typical Grout Equipment Layout



[Not to Scale]

Note: Slickline routing is for illustration only. The slickline will be configured to support filling of one primary tank riser or annulus riser at a time using fittings and diversion valves. Actual slickline routing will be per field instruction. [SRR-LWE-2014-00147]

Figure 7.3-2: Typical Grout Configuration for Type I Tanks



[SRR-CWDA-2010-00128]

Tank grout typically consists of two major states, cured and fresh. [WSRC-STI-2007-00369] The major properties of cured grout include: high compressive strength, low effective diffusion coefficient, low hydraulic conductivity, low porosity, and high dry bulk density. The fresh grout properties include: high flow, low bleed water generation, low air content, and high wet unit weight (density). Slump-flow is used as an acceptance criterion for grout delivered to the HTF and air content will be measured for information. Quality control requirements of the grout production is included as part of the grout procurement specification (C-SPP-F-00055).

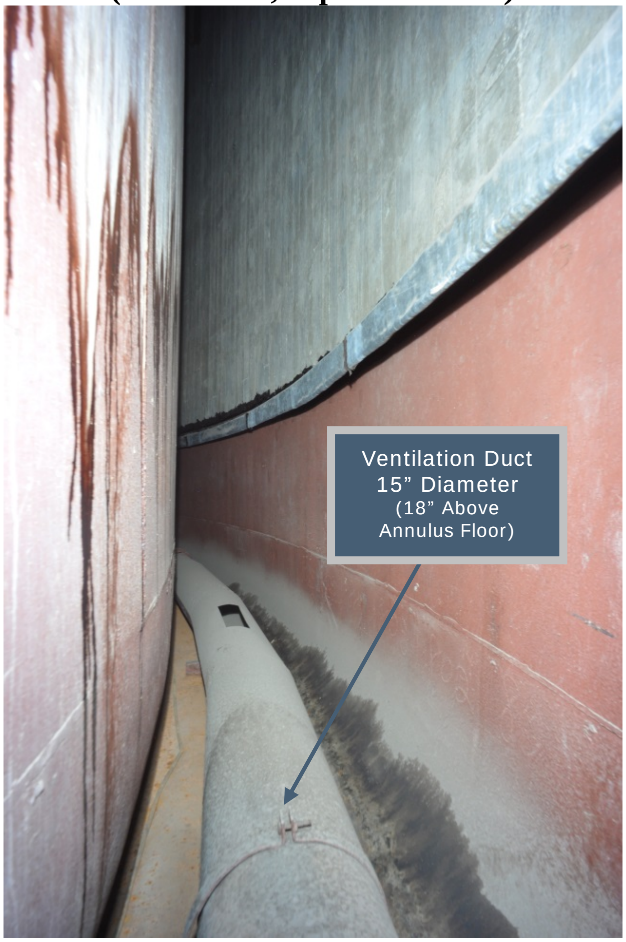
Independent testing determined that certain formulas of grout provide a superior protection for any stabilized contaminant that might remain in the waste tank. [WSRC-STI-2007-00369] The reducing grout properties associated with the Tank 12H grout are taken from the specification in *Tanks 18 and 19-F Structural Flowable Grout Fill Material Evaluation and Recommendations* (SRNL-STI-2011-00551), which are based on testing of the grout formula for waste tank fill. The HTF PA (Table 3.2-9 and Table 4.2-28) outlines the key mechanical and chemical properties used in PA modeling. A grout formula that meets the key specifications will reduce water intrusion, retard migration of residual contaminants, and inhibit a hypothetical future MOP from drilling into the waste tank.

The waste tank risers will be modified as needed to permit grout placement into the waste tank. Video cameras will be used during the grout pouring process to monitor for anomalies and potential void space formations. Each waste tank riser will be filled with grout from the top. Provisions will be made to provide delivery points into the waste tank to manage air displacement, to address bleed water build-up, and to handle any waste tank top overflow. The waste tank will be ventilated until after grouting is complete. Since the commencement of waste tank grouting requires approval of this CM, the final grouted tank configuration will be reported in the Final Configuration Report for Tank 12H. [SRR-LWE-2014-00147]

7.3.3 **Annulus Grouting**

Bulk fill grout will be introduced into the annulus between the outside radius of the annulus ventilation duct and the annulus steel pan. Initially, an approximately 6-inch deep grout layer will be placed on the annulus pan floor to support the horizontal ductwork sections during grouting. The ductwork will then be filled first through the vertical inlet piping system to the extent practicable, or until grout is observed exiting through the vent openings on top of the ductwork. As the annulus bulk fill level is raised, grout will flow through any remaining openings and into any unfilled portions of the horizontal ductwork. In parallel with bulk filling of the annulus, the vertical section of annulus ventilation inlet duct will be filled all the way to grade level with bulk fill grout. The annulus exhaust riser will be filled to grade level after the bulk fill level reaches the bottom of the riser (i.e., top of the annulus). To maintain integrity of the primary tank wall structure, grout will be poured alternately into the primary tank and the annulus to meet structural integrity requirements. The annulus risers will be filled up to the level of the riser opening planes. Figure 7.3-3 shows the annulus and ventilation duct in Tank 12H. [SRR-LWE-2014-00147]

Figure 7.3-3: View of Tank 12H Annulus and Ventilation Duct (West Riser, September 2012)



7.3.4 **Cooling Coil Grouting**

The current plan is to flush all intact cooling coils prior to the introduction of grout. The flush water will remove chromate cooling water from the coils and will ensure a uniformly wetted path exists for the grout to follow. The chromate water flushed from intact cooling coils may be collected and returned to an active waste tank, or waste collection tote. Grout will be placed into the primary tank prior to the grouting of the any cooling coils. The initial pour of grout into the waste tank will support the vertical cooling coils and help prevent failure of the vertical coils during grouting.

Coils that have been severed will be grouted from each end to the extent practicable. There may be sections of coils with breaks not connected to the coil inlets and/or outlets that cannot be internally filled. Coils that are no longer intact (e.g., failed with a guillotine break) will only be filled passively as the bulk grout is added to the tank. [SRR-LWE-2014-00147]

8.0 MAINTENANCE AND MONITORING PLANS

The FFA establishes requirements for the prevention and mitigation of releases or threats of releases at or from the HTF, and any needed remediation of soils and groundwater when all HTF waste tanks have been removed from service. Because not all waste tank systems will be removed from service at the same time, there will be an interim period where some systems remain operational, while others are removed from service. [WSRC-OS-94-42]

Following stabilization, Tank 12H will become subject to the maintenance and monitoring requirements of an IROD/RCRA Permit Modification. The tank will then be removed from the Construction Permit #17,424-IW. In the interim period following RFS until application of the IROD/RCRA Permit Modification and any subsequent needed final FFA corrective/remedial actions, Tank 12H will be subject to the following maintenance and monitoring requirements:

- Historically, groundwater monitoring has been performed in accordance with the current SRS programs that have been conducted inside and around HTF since the 1970's, as requested by SCDHEC in support of Construction Permit #17,424-IW (DHEC_01-25-1993). The *H-Area Tank Farm Groundwater Monitoring Plan and Sampling and Analysis Plan* (SRNS-RP-2012-00146) provides the requirements for groundwater monitoring. The analysis of groundwater samples is performed by a laboratory certified for applicable parameters in accordance with SCDHEC Regulation 61-81, *State Environmental Laboratory Certification Program*. Results have been and will continue to be reported annually to SCDHEC and EPA.
- Annual visual inspections of the area surrounding Tank 12H will be conducted and maintenance actions will be performed, as appropriate. The grout is the primary barrier to contaminant release. The grout, where visible, will be inspected for significant cracking. The stormwater system will be maintained to ensure that any possible water infiltration through grout is minimized. Inspections will commence within one year of grout stabilization and will be performed annually. Deficiencies will be corrected as soon as practical and will be documented by procedure. Within 30 days of detection, DOE will notify SCDHEC of any significant cracking of the grout or degradation of the stormwater system and will establish a schedule to complete necessary maintenance activities. Inspection records will be maintained until all tanks have been removed from service and the HTF OU is closed.
- Access controls for on-site workers will be provided via the Site Use Program, Site Clearance Program, work control, worker training, worker briefing of health and safety requirements, and identification signs located at the waste unit boundaries.
- EPA and SCDHEC will be notified in advance of changes in land use in accordance with the *Savannah River Site Land Use Plan* (SRNS-RP-2013-00162).
- Access controls against trespassers will be provided as consistent with the 2000 RCRA Part B Permit Renewal Application, Volume I, Section F.1, which describes the security procedures and equipment, 24-hour surveillance system, artificial or natural barriers, control entry systems, and warning signs in place at the SRS boundary. [WSRC-IM-98-30]

9.0 CONCLUSION

Bulk waste and heel removal activities performed in Tank 12H were successful in removing over 99% of the total waste from the tank primary. A summary of the results of bulk waste and heel removal campaigns conducted in Tank 12H is provided in Table 9.0-1.

Table 9.0-1: Tank 12H Primary Tank Waste Removal Details

Total Starting Volume (gallons)	~729,000 [a]
Total Solids Removed (gallons)	> 201,250
Total Solids Remaining (gallons)	< 2,000
Percent of Total Waste Volume Removed (%)	**> 99**

[a] Starting volume is based on historical high waste volume in the waste tank

Based on the information presented in this CM, DOE has determined that further waste removal efforts are not technically practicable from an engineering perspective for Tank 12H. This determination is based on the approach followed and defined in the HTF GCP.

- 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 9.0-1 shows the Tank 12H primary immediately following the completion of waste removal efforts, with approximately 3 inches of liquid remaining in the tank. Extensive waste removal efforts were performed in the tank primary (Sections 3.2 through 3.4) resulting in less than 2,000 gallons of residual material remaining. An updated panoramic photograph will be provided in the CM addendum.

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

- Analysis of Deploying an Additional Waste Removal Technology – An analysis of deploying another cleaning technology was performed that demonstrated that it was not technically practicable from an engineering perspective to continue with active waste removal activities. The analysis included such factors as technology capabilities, schedule impacts, a quantified cost summary, and a risk and benefit analysis (Section 6.0). The evaluation concluded that:

  - No new practicable technology has been identified that has reached a level of maturity for deployment to remove a significant, additional concentration of constituents of concern from Tank 12H.
  - Even if a technology could be identified and deployed, the limited benefit associated with further removal of residuals from Tank 12H does not justify the associated additional costs including the resulting delays in other risk-reducing activities in the Liquid Waste System.
  - The dose to implement additional waste removal far exceeds the marginal waste/risk reduction potentially realized if waste removal activities continue. Furthermore, the potential safety risks of executing any removal are greater than the long-term risks of leaving the residual material in place.
- Human Health and Environment Impacts – The Tank 12H residuals have been sampled to determine final inventories. Because analysis of the residual material samples is in progress, the final inventories are unknown at the time of this CM development. However, as discussed in Section 4.0, the Tank 12H forecasted inventory has been included in the modeling performed for the Tank 16H SA. The Tank 16H SA includes the fate and transport modeling results using both the final Tank 16H residual inventory and the Tank 12H forecasted residual inventory. As described in Section 5.0, there is reasonable assurance that groundwater concentrations derived from residual contamination in the HTF tanks and ancillary structures will meet the performance objectives, based on groundwater modeling performed within the Tank 16H SA. 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-2014-00106]
- Isolation Strategy – The isolation strategy demonstrates that Tank 12H will be isolated from the remainder of the HTF Waste Transfer System and the HTF support systems, securing them from any future waste processing activities (Section 7.1).
- Stabilization – DOE has evaluated stabilization alternatives in the EIS (DOE-EIS-0303) and has determined that the "Fill with Grout" alternative is the best approach to minimize human health and safety risks associated with RFS of the waste tanks (Section 7.3).
- Maintenance and Monitoring – DOE will monitor groundwater, conduct annual surface visual inspections, and control access to the HTF during the interim period between RFS of Tank 12H until final closure of the HTF OU (Section 8.0).

DOE has determined that after completion of this CM and the planned CM addendum, all HTF GCP requirements will have been met to proceed with removing Tank 12H from service. After completion of the CM addendum, DOE will be ready to stabilize the waste tank with grout. Conditional approval of this CM and subsequent approval of the CM addendum 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 and this CM.

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. Based on the information provided in this CM 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 will re-evaluate this conclusion in the CM addendum following completion of the Tank 12H SA.

10.0 REFERENCES

10 CFR 61, *Licensing Requirements for Land Disposal of Radioactive Waste*, http://www.nrc.gov/reading-rm/doc-collections/cfr/part061/, U.S. Nuclear Regulatory Commission, Washington, DC, December 22, 2011.

40 CFR 261_App VIII, *Identification and Listing of Hazardous Waste*, Office of the Federal Register, National Archives and Records Administration, Washington, DC, March 24, 2011.

10-FTF-139, *Post-Job ALARA Review – Tank 5 (Riser 8) SMP Movement to Tank 6 (Riser 8)*, Savannah River Site, Aiken, SC, September 16, 2010.

10-FTF-187, *Post-Job ALARA Review – SMP Movement Tank 5 (Riser-3) to Tank 6 (Riser-1)*, Savannah River Site, Aiken, SC, August 3, 2010.

10-FTF-198, *Post-Job ALARA Review – Post-Job ALARA Review – SMP Removal Tank 5 (Riser-1) and Store on Trailer*, Savannah River Site, Aiken, SC, January 13, 2011.

C-SPP-F-00055, *Furnishing and Delivering of Tank Closure Grout*, Savannah River Site, Aiken, SC, Rev. 3, December 3, 2012.

DHEC_01-25-1993, *Construction Permit #17,424-IW, SRS F/H-Area, Aiken and Barnwell County*, South Carolina Department of Health and Environmental Control, Columbia, SC, January 25, 1993.

DHEC_09-29-2010, Keisler, V., *Completion of Bulk Waste Removal Efforts in Tank 12*, South Carolina Department of Health and Environmental Control, Columbia, SC, September 29,2010.

DHEC-OS-2014-02-18-01, *Concurrence to Proceed to Sample and Analysis Phase of the Tank Closure Process for Tank 12H*, South Carolina Department of Health and Environmental Control, Columbia, SC, February 18, 2014.

DOE G 413.3-4A, *Technology Readiness Assessment Guide*, U.S. Department of Energy, Washington DC, September 15, 2011.

DOE M 435.1-1, Chg. 1, *Radioactive Waste Management Manual*, U.S. Department of Energy, Washington DC, June 19, 2001.

DOE O 458.1, Chg. 3, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington DC, January 15, 2013.

DOE-EIS-0303, *High-Level Waste Tank Closure Final Environmental Impact Statement*, Savannah River Site, Aiken, SC, Rev. 0, May 2002.

DOE-EIS-0303 ROD, *High-Level Waste Tank Closure Final Environmental Impact Statement Record of Decision*, Savannah River Site, Aiken, SC, Rev. 0, August 19, 2002.

DOE-SRS-WD-2013-001, *Draft Basis for Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 0, February 6, 2013.

DOE-SRS-WD-2014-001, *Basis for Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 0, September 30, 2010.

DPSPU 78-11-9, Davis, T.L., et al., *History of Waste Tank 12, 1956 through 1974*, Savannah River Site, Aiken, SC, Rev. 0, September 30, 1978.

EPA_09-29-2010 Pope, R.H., *Completion of Bulk Waste Removal (BWR) Efforts in Tank 12*, U.S. Environmental Protection Agency, September 29, 2010.

EPA_MCL_11-2012, *Regulating Public Water Systems and Contaminants Under the Safe Drinking Water Act*, U.S. Environmental Protection Agency.

EPA-OS-2014-02-19-01, *EPA Concurrence to Proceed to Sample and Analysis Phase of the Tank Closure Process for Tank 12 H*, U.S. Environmental Protection Agency, February 19, 2014.

ISBN-10: 0-309-06431-7, Committee on Mixed Wastes and National Research Council, *The State of Development of Waste Forms for Mixed Wastes: U.S. Department of Energy's Office of Environmental Management (1999)*, National Research Council, Commission on Geosciences, Environment and Resources, 1999.

LWO-LWE-2009-00203, Clark, D.L., *Tank 12 Bulk Sludge Mixing & Transfer Data for Sludge Batch 6 Engineering Log*, Savannah River Site, Aiken, SC, Rev. 0, July 23, 2009.

LWO-SPT-2008-00033, Spires, R., *Enhanced Chemical Cleaning Project Y-492 (ECC) Mission Need Statement*, Savannah River Site, Aiken, SC, Rev. 1, October 26, 2009.

M-CLC-H-03256, Grim, G.M., *Tank 12 Internal Component Solid Coating Volume*, Savannah River Site, Aiken, SC, Rev. 0, May 5, 2014.

M-CTP-H-00003, Clark, J.L., *Tank 12H Isolation Plan*, Savannah River Site, Aiken, SC, Rev. 0, July 10, 2014.

NCRP-160 (Copyright), *Ionizing Radiation Exposure of the Population of the United States (2009)*, National Council on Radiation Protection and Measurements, Bethesda, MD, March 2009.

N-ESR-G-00001, Superseded, *High Level Waste Emergency Response Data and Waste Tank Data*, Savannah River Site, Aiken, SC, Rev. 470, April 21, 2009.

SCDHEC R.61-58, *State Primary Drinking Water Regulation*, http://www.scdhec.gov/Agency/RegulationsAndUpdates/LawsAndRegulations/Water/, South Carolina, Department Of Health and Environmental Control, Columbia, SC, August 28, 2009.

SCDHEC R.61-67, *Standards for Wastewater Facility Construction*, http://www.scdhec.gov/Agency/RegulationsAndUpdates/LawsAndRegulations/Water/, South Carolina Department of Health and Environmental Control, Columbia, SC, May 2002.

SCDHEC R.61-81, *State Environmental Laboratory Certification Program*, http://www.scdhec.gov/Agency/RegulationsAndUpdates/LawsAndRegulations/, South Carolina Department of Health and Environmental Control, Columbia, SC, January 1981.

SCDHEC R.61-82, *Proper Closeout of Wastewater Treatment Facilities*, http://www.scdhec.gov/Agency/RegulationsAndUpdates/LawsAndRegulations/Water/, South Carolina Department of Health and Environmental Control, Columbia, SC, April 11, 1980.

SRNL-L3100-2009-00036, Reboul, S.H., *Solids, Density, and Rheology of Tank 12 Sludge Blends*, Savannah River Site, Aiken, SC, Rev. 0, February 12, 2009.

SRNL-L3100-2009-00084, Reboul, S.H., Click, D.R., *Physical and Radiological Analysis of Tank 12 Sample #HTF-12-09-42*, Savannah River Site, Aiken, SC, Rev. 0, April 3, 2009.

SRNL-L3100-2014-00256, *Scoping Analysis Data for Tank 12H Cooling Coil and Floor Liquid Fraction Samples*, Savannah River Site, Aiken, SC, Rev. 0, November 18, 2014.

SRNL-STI-2011-00551, Langton, C.A., Stefanko, D.B., *Tanks 18 and 19-F Structural Flowable Grout Fill Material Evaluation and Recommendations,* Savannah River Site, Aiken, SC, Rev. 0, September 2011.

SRNS-RP-2012-00146, *H-Area Tank Farm Groundwater Monitoring Plan,* Savannah River Site, Aiken, SC, Rev. 1, November 2012.

SRNS-RP-2013-00162, *Savannah River Site Land Use Plan*, Savannah River Site, Aiken, SC, Rev. 0, May 2013.

SRR-CWDA-2010-00023, Superseded, *H-Tank Farm Waste Tank Closure Inventory for Use in Performance Assessment Modeling,* Savannah River Site, Aiken, SC, Rev. 3, May 10, 2012.

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

SRR-CWDA-2010-00128, *Performance Assessment for the H-Area Tank Farm at the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 1, November 2012.

SRR-CWDA-2010-00157, *Proposal to Cease Waste Removal Activities in Tanks 5 and 6 and Enter Sampling and Analysis Phase*, Savannah River Site, Aiken, SC, Rev. 0, November 3, 2010.

SRR-CWDA-2011-00022, *Industrial Wastewater General Closure Plan for H-Area Waste Tank Systems,* Savannah River Site, Aiken, SC, Rev. 0, May 2012.

SRR-CWDA-2011-00050, *Liquid Waste Tank Residuals Sampling and Analysis Program Plan*, Savannah River Site, Aiken, SC, Rev. 2, July 2013.

SRR-CWDA-2011-00106, *Qualification and Management of K_d Data for Use in C&WDA Performance Assessments*, Savannah River Site, Aiken, SC, Rev. 0, June 15, 2011.

SRR-CWDA-2011-00117, *Liquid Waste Tank Residuals Sampling-Quality Assurance Program Plan,* Savannah River Site, Aiken, SC, Rev. 1, July 2013.

SRR-CWDA-2013-00058, *Dose Calculation Methodology for Liquid Waste Performance Assessments at the Savannah River Site,* Savannah River Site, Aiken, SC, Rev. 1, July 31, 2014.

SRR-CWDA-2013-00125, *Proposal to Cease Waste Removal Activities in Tank 12 and Enter Sampling and Analysis Phase*, Savannah River Site, Aiken, SC, Rev. 0, December 19, 2013.

SRR-CWDA-2014-00003, *SRR Waste Removal and Operational Closure Strategy,* Savannah River Site, Aiken, SC, Rev. 0, June 11, 2014.

SRR-CWDA-2014-00052, *Recommended Radionuclide and Chemical Analyte List for Tank 12*, Savannah River Site, Aiken, SC, Rev. 2, August 2014.

SRR-CWDA-2014-00106, *Tank16 Special Analysis for the Performance Assessment for the H-Area Tank Farm at the Savannah River Site,* Savannah River Site, Aiken, SC, Rev. 0, February 2015.

SRR-LWE-2010-00240, Clark, J.L., *Tank Mapping Methodology*, Savannah River Site, Aiken, SC, Rev. 1, November 28, 2012.

SRR-LWE-2010-00257, Clark, J.L., *Estimation of Tank 12 Solid Sludge Volume in Support of SB7B and Heel Removal*, Savannah River Site, Aiken, SC, Rev. 0, December 20, 2010.

SRR-LWE-2011-00099, Clark, J.L., *Estimation of Tank 12 Sludge-Solids Volume in Support of SB7B and Heel Removal*, Savannah River Site, Aiken, SC, Rev. 0, March 31, 2011.

SRR-LWE-2011-00107, Isom, W., *CY 2010 Annual SCDHEC Technology Briefing*, Savannah River Site, Aiken, SC, Rev. 0, April 25, 2011.

SRR-LWE-2011-00156, Clark, J.L., *Tank 12 Slurry Pump Run Strategy to Support In-tank Low Temperature Aluminum Dissolution and Waste Removal*, Savannah River Site, Aiken, SC, Rev. 5, August 18, 2011.

SRR-LWE-2011-00201, Pasala, N.R., *Information on the Radiological and Chemical Characterization of the Savannah River Site Tank Waste as of July 5, 2011*, Savannah River Site, Aiken, South Carolina, Rev. 0, September 26, 2011.

SRR-LWE-2012-00108, Hansen, A.G., *Applicability of SRNL Corrosion Data to Chemical Cleaning in the Tank Farms*, Savannah River Site, Aiken, SC, Rev. 0, June 7, 2012.

SRR-LWE-2012-00144, Tank 12 *Annulus Inspection Report and Cleaning Recommendation*, Savannah River Site, Aiken, South Carolina, Rev. 0, August 15, 2012.

SRR-LWE-2013-00202, Sudduth, C., et al., *Evaluation of Sludge Heel Dissolution Efficiency with Oxalic Acid Cleaning at Savannah River Site - 14205*, Savannah River Site, Aiken, SC, Rev. 0, November 11, 2013.

SRR-LWE-2014-00055, Arthur, G., *Annual SCDHEC Technology Briefing*, Savannah River Site, Aiken, SC, Rev. 0, April 23, 2014.

SRR-LWE-2014-00147, Walters, C., *Tank 12H Grout Strategy*, Savannah River Site, Aiken, SC, Rev. 0, January 28, 2015.

SRR-LWE-2014-00154, Clark, J.L., *Summary of Tank 12 Water Wash Campaigns Prior to Bulk Oxalic Acid Cleaning*, Savannah River Site, Aiken, SC, Rev. 0, October 16, 2014.

SRR-LWE-2014-00155, Clark, J.L., *Summary of Tank 12 Acid Strikes During Bulk Oxalic Acid Cleaning*, Savannah River Site, Aiken, SC, Rev. 0, October 16, 2014.

SRR-LWP-2009-00001, Superseded, *Liquid Waste System Plan*, Savannah River Site, Aiken, SC, Rev. 15, January 11, 2010.

SRR-LWP-2011-00001, Chew, D.P., *SRR Operations Performance Fiscal Year 2010 Summary*, Savannah River Site, Aiken, SC, Rev. 0, March 1, 2011.

SRR-LWP-2012-00025, Chew, D.P., *SRR Operations Performance Fiscal Year 2011 Summary*, Savannah River Site, Aiken, SC, Rev. 0, June 7, 2012.

SRR-LWP-2012-00037, Clark, J.L., *Tank 12 Waste Volume Determinations During BOA - Water Washes*, Savannah River Site, Aiken, SC, Rev. 0, May 22, 2012.

SRR-LWP-2013-00001, Chew, D.P., *SRR Operations Performance Fiscal Year 2012 Summary*, Savannah River Site, Aiken, SC, Rev. 0, June 13, 2013.

SRR-LWP-2013-00042, Superseded, Clark, J.L., *Tank 12 Addendum to Bulk Oxalic Acid Cleaning Operating Plan - pH Sampling*, Savannah River Site, Aiken, South Carolina, Rev. 0, June 18, 2013.

SRR-LWP-2014-00002, Chew, D.P., *SRR Operations Performance Fiscal Year 2013 Summary*, Savannah River Site, Aiken, SC, Rev. 0, June 8, 2014.

SRR-STI-2010-00015, Ketusky, E., et al., *Enhanced Chemical Cleaning: Effectiveness of the UV Lamp to Decompose Oxalates – 10502*, Savannah River Site, Aiken, SC, February 4, 2010.

SRR-STI-2012-00022, Keefer, M.T., et al., *Sludge Heel Removal by Aluminum Dissolution at Savannah River Site – 12390*, Savannah River Site, Aiken, SC, Rev. 0, February 26, 2012.

SRR-WRC-2011-0004, Davis, N., *Revised Heel Removal Approach for Tanks 11 & 12*, Savannah River Site, Aiken, SC, Rev. 0, May 11, 2011.

S-TSR-G-00001, *Concentration, Storage, and Transfer Facilities Technical Safety Requirements*, Savannah River Site, Aiken, SC, Rev. 45, December 2014.

U-CLC-G-00023, Hester, J.R., *Tank 12H Estimated Salt Volume*, Savannah River Site, Aiken, SC, Rev. 0, January 14, 2004.

U-ESR-H-00062, Whitehead, D.A., *Tank 12 Waste Removal Operating Plan, Tank Closure Preparation Project*, Savannah River Site, Aiken, SC, Rev. 4, October 1, 2009.

U-ESR-H-00085, Bhatt, P.N., *Estimation of Tank 12 Solid Sludge Volume After Sludge Batch IV Transfer*, Savannah River Site, Aiken, SC, Rev. 0, June 25, 2009.

U-ESR-H-00093, Whitehead, D.A., *Estimation of Tank 12 Solid Sludge Volume After Sludge Batch 7 and Bulk Waste Removal*, Savannah River Site, Aiken, SC, Rev. 0, September 7, 2010.

U-ESR-H-00103, Clark, J.L., *Tank 12 Bulk Oxalic Acid Cleaning Operating Plan*, Savannah River Site, Aiken, SC, Rev. 3, February 27, 2014.

U-ESR-H-00125, Clark, J.L., *Tank 12 Final Volume Determination and Uncertainty Estimate*, Savannah River Site, Aiken, SC, Rev. 0, October 13, 2014.

U-SOW-H-00010, Harris, D., *Scope of Work and Strategy Chemical Cleaning of F-Tank Farm and H-Tank Farm Tanks*, Savannah River Site, Aiken, SC, Rev. 0, April 30,2012.

WDPD-14-20, Hennessey, B.T., *Request for Concurrence to Proceed to Sample and Analysis Phase of the Tank Closure Process for Tank 12H (CERCLIS Number: 89)*, Savannah River Site, Aiken, SC, January 21, 2014.

WSRC-IM-98-30, *2000 Renewal Application for a RCRA Part B Permit*, Vol. I, Part 1, Section F.1, Savannah River Site, Aiken, SC, Rev. 1, January 2002.

WSRC-OS-94-42, *Federal Facility Agreement for the Savannah River Site*, Savannah River Site, Aiken, SC, August 16, 1993.

WSRC-SA-2002-00007, *Concentration, Storage, and Transfer Facilities*, Savannah River Site, Aiken, SC, Rev. 15, September 2013.

WSRC-STI-2007-00369, *Hydraulic and Physical Properties of Tank Grouts and Base Mat Surrogate Concrete for FTF Closure*, Savannah River Site, Aiken, SC, Rev. 0, October 29, 2007.

WSRC-STI-2007-00641, Langton, C.A., et al., *Grout Formulations and Properties for Tank Farm Closure*, Rev. 0, November 12, 2007.

WSRC-STI-2008-00366, Hay, M.S., et al., *Determination of the Fraction of Gibbsite and Boehmite Forms of Aluminum in Tank 51H Sludge*, Savannah River Site, Aiken, SC, Rev. 0, August 2008.

WSRC-TR-97-0102, Caldwell, T.B., *Tank Closure Reducing Grout*, Savannah River Site, Aiken, SC, Rev. 0, April 1997.

X-CLC-H-00896, Sudduth, C.B., *Tank 12H Flowsheet for Bulk Oxalic Acid Cleaning (BOAC)*, Savannah River Site, Aiken, SC, Rev. 0, June 28, 2012.

X-ESR-H-00599, Sudduth, C.B., *Effectiveness of Tank 12 Bulk Oxalic Acid Cleaning (BOAC)*, Savannah River Site, Aiken, SC, Rev. 0, March 13, 2014.

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.

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	
Tank 13		
Tank 14		
Tank 15		
Tank 16	SRR-CWDA-2013-00091	
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		