WRPS-51713-FP
Revision 0

Overview of Enhanced Hanford Single-Shell Tank (SST) Integrity Project - 12128

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-08RV14800

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ABSTRACT

To improve the understanding of the single-shell tanks integrity, Washington River Protection Solutions, LLC, the USDOE Hanford Site tank contractor, developed an enhanced Single-Shell Tank (SST) Integrity Project in 2009. An expert panel on SST integrity, consisting of various subject matters experts in industry and academia, was created to provide recommendations supporting the development of the project. This panel developed 33 recommendations in four main areas of interest: structural integrity, liner degradation, leak integrity and prevention, and mitigation of contamination migration, Seventeen of these recommendations were used to develop the basis for the M-45-10-1 Change Package for the Hanford Federal Agreement and Compliance Order, which is also known as the Tri-Party Agreement.

The change package identified two phases of work for SST integrity. The initial phase has been focused on efforts to envelope the integrity of the tanks. The initial phase was divided into two primary areas of investigation: structural integrity and leak integrity. If necessary based on the outcome from the initial work, a second phase would be focused on further definition of the integrity of the concrete and liners. Combined these two phases are designed to support the formal integrity assessment of the Hanford SSTs in 2018 by Independent Qualified Registered Engineer.

The work to further define the DOE's understanding of the structural integrity SSTs involves preparing a modern Analysis of Record using a finite element analysis program. Structural analyses of the SSTs have been conducted since 1957, but these analyses used analog calculation, less rigorous models, or focused on individual structures. As such, an integrated understanding of all of the SSTs has not been developed to modern expectations. In support of this effort, other milestones will address the visual inspection of the tank concrete and the collection of concrete core samples from the tanks for analysis of current mechanics properties.

The work on the liner leak integrity has examined the leaks from 23 tanks with liner failures. Individual leak assessments are being developed for each tank to identify the leak cause and location. Also a common cause study is being performed to take the data from individual tanks to look for trends in the failure. Supporting this work is an assessment of the leak rate from tanks at both Hanford and the Savannah River Site and a new method to locate leak sites in tank liner using ionic conductivity. A separate activity is being conducted to examine the propensity for corrosion in select single shell tanks with aggressive waste layers.

The work for these two main efforts will provide the basis for the phase two planning. If the margins identified aren't sufficient to ensure the integrity through the life of the mission, phase two would focus on activities to further enhance the understanding of tank integrity. Also coincident with any phase-two work would be the integrity analysis for the tanks, which would be complete in 2018. With delays in the completion of waste treatment facilities at Hanford, greater reliance on safe, continued storage of waste in the single shell tanks is increased in importance. The goal of integrity assessment would provide basis to continue SST activities till the end of the treatment mission.

INTRODUCTION

The mission of the River Protection Project (RPP) is to store, retrieve, treat, and dispose of the highly radioactive waste in Hanford Site tanks in an environmentally sound, safe, and cost-effective manner. The waste is stored in 28 active double-shell tanks and 149 single shell tanks. Although new waste additions stopped in 1980, the single-shell tanks (SSTs) continue to store over 30 million gallons of radioactive waste left over from decades of plutonium production for defense purposes. In 2004, the last pumpable liquid was removed from the SSTs except for those tanks being retrieved.

BACKGROUND

Delays in the construction and completion of the Hanford Waste Treatment and Immobilization Plant have resulted in the realization that waste will continued to be stored in these tanks for several more decades, resulting in a service lifetime of nearly 100 years. As result of these delays and to improve the understanding of SSTs integrity, the Department of Energy and Washington River Protection Solutions, LLC (WRPS), the USDOE Hanford Site tank contractor, developed an enhanced SST Integrity Project (SSTIP) in 2009. An expert panel on SST integrity, consisting of various subject matters experts in industry and academia, was created to provide recommendations supporting the development of the project. Working with the Washington State Department of Ecology, key recommendations were used to develop the basis for the M-45-10-1 Change Package for the Hanford Federal Agreement and Compliance Order, which is also known as the Tri-Party Agreement.

DESCRIPTION OF THE SINGLE-SHELL TANK SYSTEM

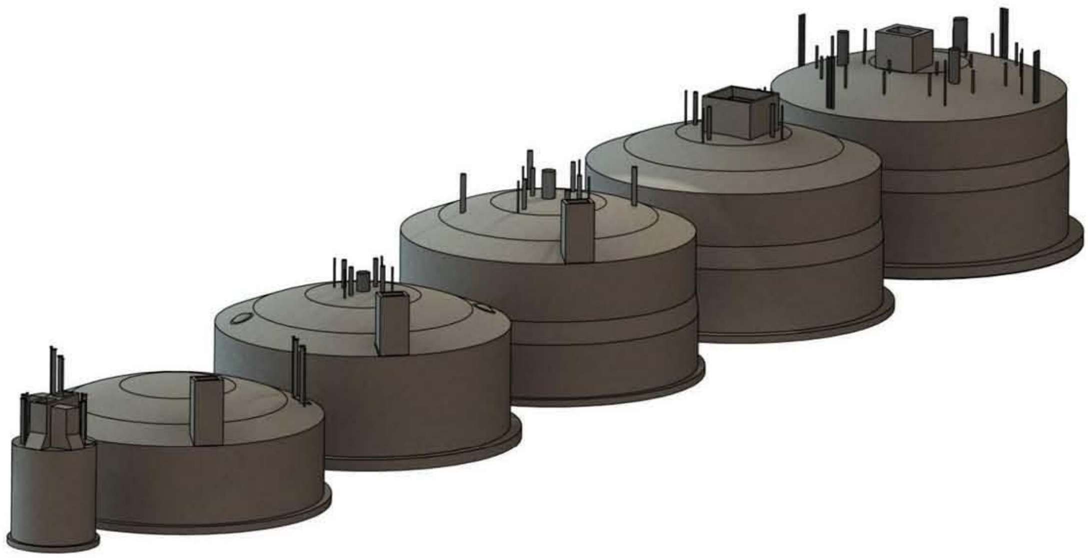
The Hanford radioactive waste is contained in 149 single-shell tanks (SSTs) and 28 double-shell tanks (DSTs). The SST tank farms were constructed over a 20 year period as needed to support the reprocessing of fuel. Four farms were started in late 1943; two were completed in 1944, and two were completed in 1945. The rest of the SST farms were started and finished at various times between 1946 and 1964, see Figure 1 for typical construction photo. The first four farms consisted of four 55,000 gallon tanks and twelve 530,000 gallon tanks. The other farms were built with three different capacities: 530,000, 750,000, and 1,000,000 gallons. In total, 149 SSTs, in 12 farms, were built for the storage of radioactive wastes at the Hanford Site.

Figure 1 – BX tank farm under construction in 1947

As previously stated, four different tank types were constructed (see Figure 2). The first, Type I, have a 20 foot diameter, 38 foot height, and hold 55,000 gallons. The second, Type II, have a 75 foot diameter, 32 foot height, and hold 530,000 gallons. The third, Type III, also have a 75 foot diameter, but had a 39 foot height, and hold 750,000 gallons. The fourth, Type IV, was broken down into three sub-types. All three Type IV tanks – Types IVA, IVB, and IVC – had a 75 foot diameter and hold 1,000,000 gallons, with heights ranging from 46 feet to 48.75 feet.

In addition to the increasing volume of the tanks, other design features changed over the years. The Type I have 15-inch thick flats lids and all other tank types have 15-inch thick concrete domes. The Type I and Type II tanks both have 12-inch thick reinforced concrete walls, and dished bottoms. The Type III tanks also have dished bottoms, but the walls were increased to 15 inches The lower portion of the tank wall on Type IV tanks was increased to 24 inches to accommodate the increased wall height. The Type IV tanks went to flatter bottom designs: pan (or with a slight depression in the center) for the Type IVA tanks and flat for the other Type IV tanks. The bottom and the wall were welded with a fillet weld for the Type IVA and IVB tanks, but the Type IVC design has a 4-inch radius knuckle. For the increased heat loaded in the Type IV tanks, they were equipped with Air Lift Circulators up to four in the Type IVA tanks, four in the Type IVB tanks, and 22 in the Type IVC tanks.

Figure 2 - Types, Sizes and Nominal Volumes of SSTs



TYPE I	TYPE II	TYPE III	TYPE IVA	TYPE IVB	TYPE IVC
55 KGAL	530 KGAL	750 KGAL	1 M GAL	1 M GAL	1 M GAL
241-B 241-C 241-T 241-U	241-B 241-BX 241-C 241-T 241-U	241-BY 241-S 241-TX 241-TY	241-SX	241-A	241-AX
16 TANKS	60 TANKS	48TANKS	15 TANKS	6 TANKS	4 TANKS

Early failures of some single shell tanks, some potentially from stress corrosion cracking (SCC) of the SSTs carbon-steel liners, resulted in leakage of waste from the SSTs to the surrounding soil. This leakage led to a decision by the U.S. Atomic Energy Commission (predecessor to the U.S. Energy Research and Development Administration and subsequently the DOE) in the 1960s to initiate construction of DSTs with improved design, materials, and construction. The construction of the DSTs began in 1968 with the sixth farm being completed in 1986. All of the DSTs have a nominal million-gallon waste capacity. The free liquids from SSTs have been transferred to DSTs as part of the SST interim stabilization program, which was completed in fiscal year (FY) 2005. Eventually, the remaining solids (i.e., sludge and salt cake) and interstitial liquid in the SSTs will also be retrieved and transferred to DSTs for subsequent processing and disposal; after that, the disposition of the SSTs will take place per the applicable requirements.

At this point, the structural integrity program for SSTs is limited to ensuring that structural adequacy is maintained throughout SST waste retrieval and closure. However, since negotiations under the Tri-Party Agreement related to the schedule for waste treatment and vitrification have extended the use of the SSTs, the DOE established an extensive program for SST integrity.

Single Shell Tank Operational History

The SSTs received alkaline waste from multiple nuclear fuel reprocessing operations, starting in 1944. The initial radioactive wastes were principally derived from three different chemical processing operations, each of which produced several different types of waste; the bismuth phosphate process, Reduction Oxidation (Redox) process, and Plutonium Uranium Extraction (PUREX) process. The bismuth phosphate process only recovered plutonium from irradiated reactor fuels. The Redox and PUREX processes recovered both plutonium and uranium from the fuel.

The bismuth phosphate wastes discharged to the tanks were later processed to recover uranium from the wastes by using the tributyl phosphate (TBP) process. Potassium ferrocyanide was used to scavenge cesium ion from this waste. The oldest tanks (241-B, 241-BX, 241-BY, 241-C, 241-T, 241-TX, 241-TY, and 241-U farms) were constructed to receive waste from bismuth phosphate plants and received other wastes (e.g., low heat wastes from the Redox and PUREX plants and waste from uranium metal recovery). The Redox high heat wastes were stored in the 241-S and 241-SX farms. The PUREX high heat wastes were stored in 241-A, and 241-AX farms. The 241-SX, 241-A, and 241-AX designs allowed the storage of boiling wastes so water could be removed from the tanks to conserve space for the retention of radioactive materials. Tanks in the 241-A, -AX, and –SX Farms experienced high temperatures ranging from 200° F to 594° F. Other operations including the in-tank solidification (ITS) and tank farm evaporators were used to remove water and concentrate the wastes.

Waste additions to the SSTs ceased in 1980 and pumpable liquids have been transferred from the SSTs to the double-shell tanks (DSTs). SST wastes are slated for retrieval and treatment in a Waste Treatment Plant and Immobilization (WTP) that is currently under construction. Technical issues have delayed the schedule for initiating operations of the WTP. The delays to the WTP will necessitate extended storage in the SSTs, most of which are beyond their design life. The most recently built, 241-AX farm, tanks had a design life of 25 years which expired in 1990. Design life is based on steel liner corrosion rather than concrete degradation.

The Expert Panel and Genesis of and Single-Shell Tank Integrity Program

With the recognition that continued storage of waste in the SSTs would be required for decades into the future, it was essential to takes steps to better understand the integrity of these aging structures. An expert panel on SST integrity, consisting of various subject matters experts in industry and academia, was created to provide recommendations supporting the development of the project. The panel makeup is shown in Figure 3. The expert panel was convened in 2009 and met several times to address SST integrity concerns as detailed in Table I.

Figure 3 – Single-Shell Tanks Integrity Expert Panel

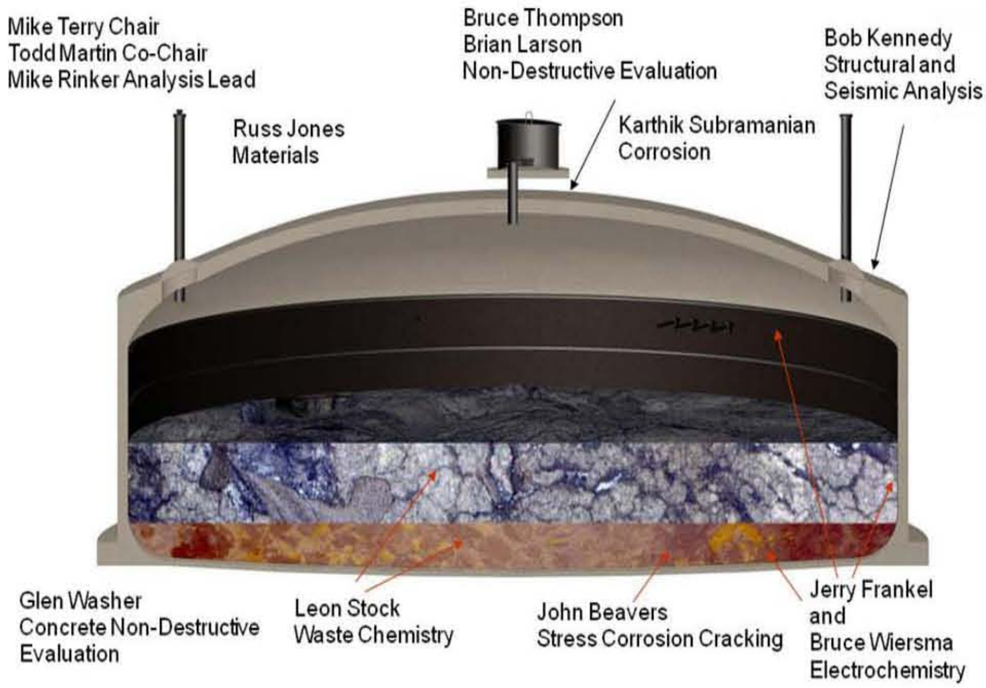


Table I - Single-Shell Tanks Integrity Expert Panel Meetings and Output

Meeting	Dates	Purpose	Documentation
First	January 26-28, 2009	Provide information to the Panel about SSTs.	WRPS-40656, *Summary of First Single-Shell Tank Integrity Expert Panel Workshop - January 2009 (1)*
Second	April 29-May 1, 2009	Respond to questions from Panel and for Panel members to present information based on assignments from the first meeting.	WRPS-42005, *Summary of Second Single-Shell Tank Integrity Expert Panel Workshop - April 2009* RPP-RPT-43116, *Expert Panel Report for Hanford Site Single-Shell Tank Integrity Project (2)*
Third	January 20-21, 2010	New report to reflect new guidance.	RPP-RPT-45921, *Single-Shell Tank Integrity Expert Panel Report (3)*
Fourth	February 23-25, 2011	Review Progress, Refine Recommendations, Discuss Continued Panel Oversight	RPP-RPT-49272, *Fourth Single-Shell Tank Integrity Project Expert Panel Meeting (4)*

The expert panel developed 33 recommendations in four main areas of interest: structural integrity (SI-X), liner degradation (LD-X), leak integrity and prevention (LIP-X), and mitigation of contamination migration (MCM-X) and documented their findings in RPP-RPT-43116, *Expert Panel Report for Hanford Site Single-Shell Tank Integrity Project (5)*, for implementation of an enhanced single-shell tank integrity project (SSTIP). The panel focused on four key elements for the tank integrity project: confirmation of tank structural integrity, assessment of the likelihood of future tank liner degradation, leak identification and prevention, and, mitigation of contaminant migration. In addition, the panel identified the key "*top ten' primary recommendations that form the foundation of a robust SSTIP".*

1. Recommendation SI-1, Perform Modern Structural Analyses or Analysis of Record (AOR)
2. Recommendation SI-2, Perform Dome Deflection Surveys
3. Recommendation SI-3, Obtain and Test Sidewall Core
4. Recommendation SI-4: Perform Non-Destructive Evaluation of Concrete
5. Recommendation LD-1, Expand Leak Assessment Reports
6. Recommendation LD-2, Avoid Inadvertent Addition of Water and Chloride to SSTs
7. Recommendation LIP-1, Continue Leak Detection Monitoring and Best Management Practices and Install Enhanced External SST Monitoring
8. Recommendation LIP-2, Avoid the Addition of Water-Insoluble Absorbents to SSTs
9. Recommendation LIP-3, Continue Use of High Resolution Resistivity
10. Recommendation MCM-1, Install Surface Barrier over SST Farms

WRPS produced implementing documentation in RPP-PLAN-45082, *Implementation Plan for the Single-Shell Tank Integrity Project (6)* that addresses these 10 primary recommendations as well as six additional secondary recommendations, identifying the scope, work plan, and work schedule to complete each recommendation.

In addition to the top 10 primary recommendations, the six secondary recommendations that WRPS recommended to pursue further are:

1. SI-5,Test Dome Concrete and Rebar 'Plugs
2. SI-6, Develop Engineering Mechanics Document
3. LD-3, Examine "non-compliant" wastes at 25°C
4. LD-5, Determine Ammonia Corrosion Control Concentration
5. LD-6, Assess SST Waste Compositional Variation
6. LIP-8, Assess the Feasibility of Testing for Ionic Conductivity Between Inside and Outside of SSTs

After release of the Panel's first report, RPP-RPT-43116, DOE/ORP and WRPS requested additional consideration from the Panel on overall SST integrity and evaluation of proposed "future use" strategies for SSTs to address DST waste volume concerns and impacts on retrieval schedules. A January 2010 Workshop, was held and second expert panel report was produced, RPP-RPT-45921, *Single-Shell Tank Integrity Expert Panel Report (3),* which includes commentary and future use recommendations.

Regulator Acceptance

To provide regulatory framework for execution of the SSTIP, in late 2010, a series of working meetings were held with DOE/ORP, Washington State Department of Ecology, and WRPS. These meetings were held to develop a consensus opinion of what elements of the 33 recommendations should be implemented near- term, with milestones and dates, and what recommendations were held for possible re-evaluation in 2015 or not to be implemented. A Phased Approach for Implementation of the SSTIP was recommended with the goal of developing a sufficient data to support a re-assessment of SST integrity by an Independent Qualified Registered Professional Engineer (IQRPE). A series of 8, enforceable interim milestones and 12 target milestones were established. A final change package for, known as the M-45-10-1 Change Package, for the Hanford Federal Facility Agreement and Consent

Order, which is also known as the Tri-Party Agreement was approved by DOE and State at the start of CY 2011.

The change package was organized into two principal areas, with two summary activities collecting sub-ordinate tasks; a Summary Conclusions report on Leak Integrity (M-045-91F) and a Summary Conclusions report on Structural Integrity (M-045-91G). Each summary activity collects data and information from a number of supporting, “target” activities. The basic logic for the summary project milestones is shown in Figure 4. The complete description of the Primary and Secondary Recommendations to be implemented during Phase I of the SSTIP are listed in the Appendix.

There is a major project assessment point created in 2015 with the M-045-91H milestone and completion of Phase I activities. At this point, the Project, along with the regulators, will determine the effectives of the preceding Phase I actions and determine which additional panel recommendations should become Phase II activities and milestones. The entire SSTIP leads to a culminating effort in 2018 (the M-045-91I milestone) with the IQRPE Certification of SST structural Integrity for the remainder of the mission (or such time as IQRPE believes is justified). The complete SSTIP milestone logic is shown in Figure 5.

Fiscal Year 2011 Progress

Progress on SSTIP Activities was brisk and significant. An effective organization structure was established and critical positions staffed. Special expertise was obtained through the use of contracts. A total of five Tri-Party Agreement milestones were met and significant progress made on a number of others. The contractor, DOE and the regulatory met regularly to ensure smooth progress and acceptable completion. The work completed in 2011 included the following tasks, many of which are described in detail in other papers.

The visual inspection of the interior of the first 12 SSTs was completed, to monitor for signs of concrete cracking, spalling, or other damage. Criteria for inspection are documented in RPP-PLAN-46847, “*Visual Inspection Plan for Single-Shell Tanks and Double-Shell Tanks*”*(7)*. The results for the first inspection were documented in RPP-RPT-48194, “*Fiscal Year 2010 Visual Inspection Report for Single-Shell Tanks*”(8).

In support of obtaining a concrete core of from the sidewall of SST that operated at high temperature, several activities were completed and documented. The tank selection was completed and sample analysis requirements determined, with regulator input using the data quality objectives (DQO) process. The DQO is documented in RPP-49300, “*Data Quality Objectives for Single-Shell Tank Sidewall Coring Project*”*(9)*, and the sampling and analysis plan is documented in RPP-PLAN-50182, “*Sampling and Analysis Plan for the Single-Shell Tank Sidewall Coring Project*”*(10)*. A cold demonstration of sidewall coring, an essential prerequisite, was guided by RPP-PLAN-47369, “*Core Drilling Demonstration Plan for a Single-shell Tank Sidewall Coring Project*”*(11)* and successfully completed as described in RPP-RPT-50714, “*Demonstration Report for the Single-Shell Tank Sidewall Coring Project*”*(12).*

Figure 4 – Hanford Federal Facility Agreement and Consent Order Milestone Logic for Summary Leak Integrity and Summary Structural Integrity Activities

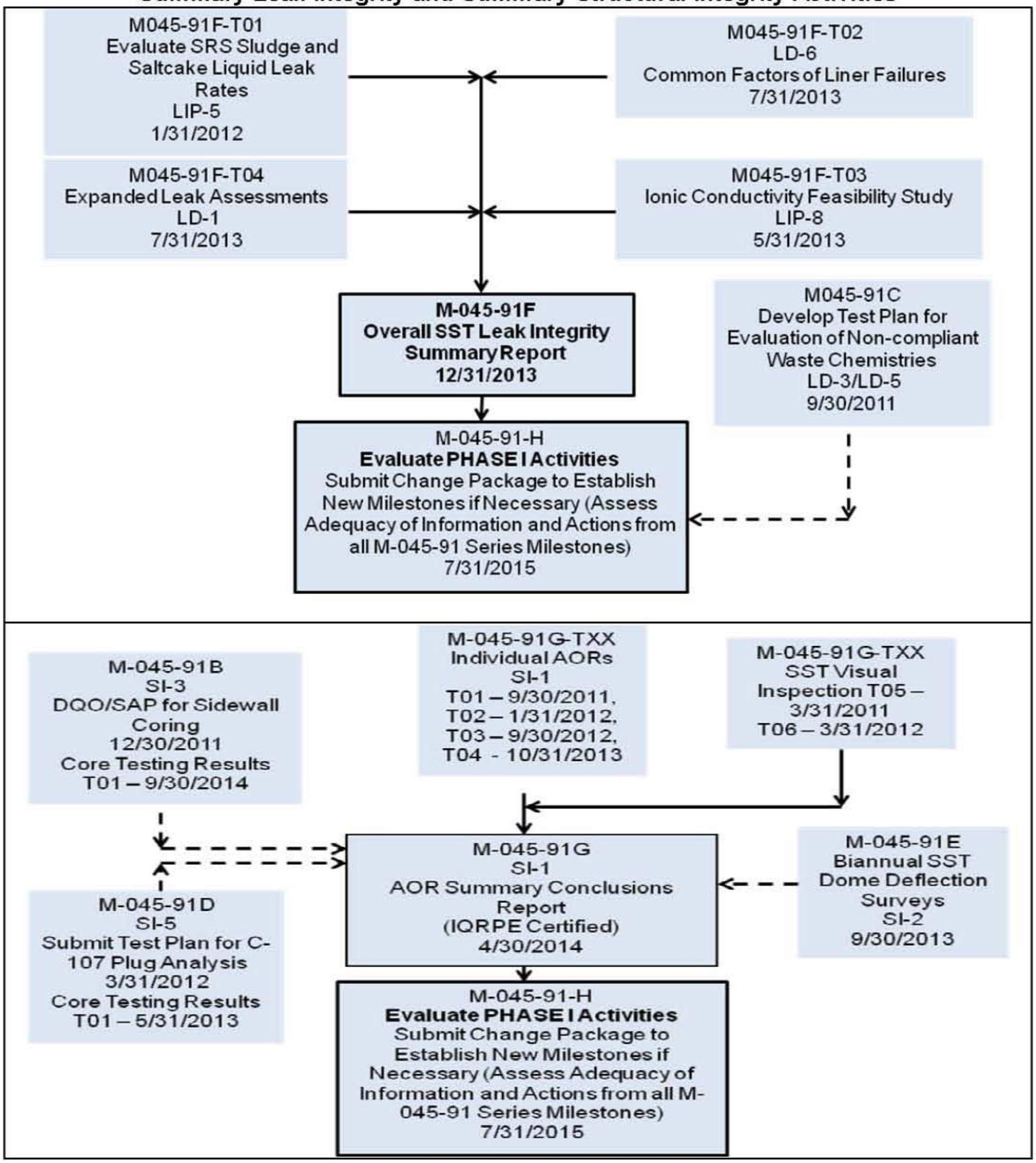
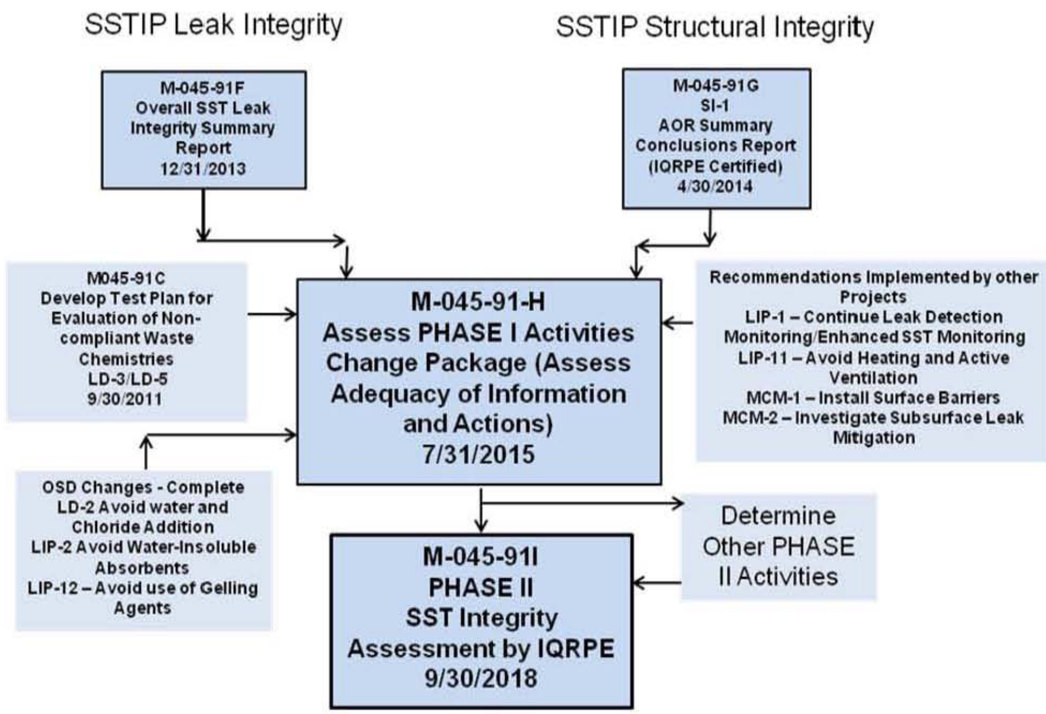


Figure 5 – Overall Hanford Federal Facility Agreement and Consent Order For Single-Shell Tank Integrity Project Logic



Concrete cores were obtained from a SST concrete dome for analysis of mechanical properties as stated in RPP-PLAN-48753, "*Analytical Test Dome Plan for the Removed 241-C-107 Dome Concrete and Rebar*" *(13)*, and shipped to an offsite commercial testing laboratory for analysis.

To understand the potential for liner corrosion in select single tanks with potentially aggressive chemistry, the RPP-PLAN-50077, "*Test Plan to Evaluate the Propensity for Corrosion in Single-Shell Tanks*"(14), was developed guided by RPP-49674, "*Single-Shell Tank Corrosion Chemistry Data Quality Objectives*"(15). The DQO was developed with regulatory input. Scoping studies and coupon tests were started in onsite laboratories.

The detailed structural analysis of SSTs was initiated with the completion of analysis on Type II and III structures reported in RPP-RPT-49989, "*Single-Shell Tank Integrity Project Analysis of Record Hanford Type II Single-Shell Tank Thermal and Operating Loads and Seismic Analysis*" *(16)* and RPP-RPT-49990, "*Single-Shell Tank Integrity Project Analysis of Record Hanford Type III Single-Shell Tank Thermal and Operating Loads and Seismic Analysis*" *(17)*.

To improve DOE's ability to verify the integrity SST liners, WRPS contracted with Dr. Jerry Frankel of the Ohio State University to investigate the feasibility of using the presence of ions in the waste from a leak to detect the presence of ionic-conductive pathways in the tank liners.

Although the initial concept was shown to lack the sensitivity required for small leaks, an alternate method of monitoring differences in corrosion potential was suggested.

Work on other leak integrity milestones was also significant. A methodology for using a cooperative process with site regulators for the determination of past SST liner Leak Cause and Locations was developed. The leak cause and locations analysis was completed and documented for 13 of the SSTs. This work challenges long-held assumptions and beliefs about past Hanford SST leaks.

Significant progress was made on determination of the common factors of SST liner failure. Integrated with the Liner Leak Cause and Location effort, new and unique causative factors for liner leaks were identified.

Fiscal Year 2012 Plan and Path Forward.
Budget shortfalls at Hanford during FY 2012 have resulted in all SSTIP work being suspended. The majority of project staff and support staff have been re-assigned to other work. Continued progress on SSTIP is on hold pending future budget and prioritization of work activities.

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4. RPP-RPT-49272, 2011, *Fourth Single-Shell Tank Integrity Project Expert Panel Meeting,* Rev. 0, M.T. Terry, Washington River Protection Solutions, Richland, Washington.

5. RPP-RPT-43116, 2009, *Expert Panel Report for Hanford Site Single-Shell Tank Integrity Panel,* Rev. 0, M.T. Terry and K. B. Boomer, Washington River Protection Solutions, Richland, Washington.

6. RPP-PLAN-45082, 2010, *Implementation Plan for the Single-Shell Tank Integrity Project*, Rev. 0, E.C. Shallman, Washington River Protection Solutions, Richland, Washington.

7. RPP-PLAN-46847, 2010, "*Visual Inspection Plan for Single-Shell Tanks and Double-Shell Tanks",* Rev. 0, J.K. Engeman, Washington River Protection Solutions, Richland, Washington.

8. RPP-RPT-48194, 2010, "*Fiscal Year 2010 Visual Inspection Report for Single-Shell Tanks*", Rev. 0, J. P. Robocker, Washington River Protection Solutions, Richland, Washington.

9. RPP-49300, 2011, "*Data Quality Objectives for Single-Shell Tank Sidewall Coring Project",* Rev. 0, R. S. Rast, Washington River Protection Solutions, Richland, Washington.

10. RPP-PLAN-50182, 2011, "*Sampling and Analysis Plan for the Single-Shell Tank Sidewall Coring Project",* Rev. 0, R. S. Rast, Washington River Protection Solutions, Richland, Washington.

11. RPP-PLAN-47369, 2011, "*Core Drilling Demonstration Plan for a Single-shell Tank Sidewall Coring Project",* Rev. 0, R. S. Rast, Washington River Protection Solutions, Richland, Washington.

12. RPP-RPT-50714, 2011, "*Demonstration Report for the Single-Shell Tank Sidewall Coring Project",* Rev. 0, R. S. Rast, Washington River Protection Solutions, Richland, Washington.

13. RPP-PLAN-48753, 2011, "*Analytical Test Dome Plan for the Removed 241-C-107 Dome Concrete and Rebar,* Rev. 0, R. S. Rast, Washington River Protection Solutions, Richland, Washington.

14. RPP-PLAN-50077, 2011, "*Test Plan to Evaluate the Propensity for Corrosion in Single-Shell Tanks*," Rev. 0, K.D. Boomer and R.B. Wyrras, Washington River Protection Solutions, Richland, Washington.

15. RPP-49674, 2011, "*Single-Shell Tank Corrosion Chemistry Data Quality Objectives*" Rev. 0, D. L. Banning, Washington River Protection Solutions, Richland, Washington.

16. RPP-RPT-49989, 2011, "*Single-Shell Tank Integrity Project Analysis of Record Hanford Type II Single-Shell Tank Thermal and Operating Loads and Seismic Analysis"* Rev. 0, R. S. Rast, Washington River Protection Solutions, Richland, Washington.

17. RPP-RPT-49990, 2011, "*Single-Shell Tank Integrity Project Analysis of Record Hanford Type III Single-Shell Tank Thermal and Operating Loads and Seismic Analysis"* Rev. 0, R. S. Rast, Washington River Protection Solutions, Richland, Washington.

Appendix – Primary and Secondary Recommendations Implemented during Phase I of the Single-Shell Tank Integrity Project.

Recommendation	**Description**
SI-1, Perform Modern Structural Analyses	*The Panel recommends performing modern structural analyses (including seismic) on representative samples of SSTs. Such analyses are necessary to understand the structural integrity of the SSTs during a seismic event. The analysis will be useful in answering the following questions: How much rebar must remain to achieve adequate structural integrity under a major seismic event? What is the level of confidence that at least this amount of rebar cross-sectional area exists and will remain present for the operating life of the tanks (e.g., 20 to 50 additional years)? What is the minimum required concrete strength?*
SI-2, Perform Dome Deflection Surveys	*The Panel recommends continuation of the current dome deflection survey program. The program should be augmented to obtain dome deflection data near the haunch of the domes. The dome surveys are important as any future potential for dome collapse would be preceded by excessive downward dome deflection. The haunch data is important to determine whether dome deflections are due to downward displacement of the dome or of the footing under the sidewall.*
SI-3, Obtain and Test Sidewall Core	*The Panel recommends obtaining and testing a vertical core from the entire depth of the sidewalls for two tanks that have leaked and had been operated at high temperatures for extended periods. Such cores will provide important data about the structural condition of concrete and rebar in the sidewalls.*
SI-4, Perform Non-Destructive Evaluation of Concrete	*The Panel emphasizes the importance of the hierarchical aspect of this recommendation. Initially, the Panel recommends the application of two technologies (1) visual inspection of domes to identify cracks in excess of 1/16 inch wide, rust stains on the concrete, or spalling of concrete, and (2) utilization of a 'thumper truck' to determine the modulus of the dome concrete. The modulus correlates with concrete strength and controls the degree of deformation that will occur under loading.* *Further development and deployment of non-destructive evaluation technologies such as guided wave propagation should occur in the event initial SSTIP activities (e.g., visual inspection, modeling, and vertical core results) indicate potential concrete degradation.*
LD-1, Expand Leak Assessment Reports	*The Panel recommends continuation of the preparation of Leak Assessment Reports for each tank farm. The Panel found the Leak Assessment Report for 241-A and 241-AX Tank Farms to be very helpful in understanding the status of data and information about both known and assumed leaker tanks. The discussion for each tank should include an operating summary, an operating history, an analysis of the leak location and cause, a waste loss estimate, commentary on the nature and extent of the ground contamination, and a conclusion.*

LD-2, Avoid Inadvertent Addition of Water and Chloride to SSTs	*To avoid creating conditions that could lead to liner corrosion, the Panel recommends that operational procedures are implemented to prevent the inadvertent addition of water and chloride ion to the SSTs. The impact of water intrusion and unintended increases in chloride ion concentrations should be evaluated on a tank-by-tank basis*
LIP-1, Continue Leak Detection Monitoring and Best Management Practices and Install Enhanced External SST Monitoring	*The Panel recommends continuing current LDM and Best Management Practices to monitor for leaks. Further, the Panel recommends installing enhanced monitoring based on potential leak risks at each tank farm. The 241-T Tank Farm Interim Cover Test has proved an excellent system for tracking infiltration of meteoric water. Increasing the depths and expanding the aerial extent of monitoring similar to this test will provide an excellent system for early detection and tracking of leaks.*
LIP-2, Avoid the Addition of Water-Insoluble Absorbents to SSTs	*The Panel considered the addition of absorbents to the SSTs to further immobilize liquids. However, the Panel recommends avoiding the addition of water-insoluble solid absorbents to the SSTs, as such additives do not appear effective in immobilizing water, will interfere with the future retrieval of wastes, and may adversely impact WTP operations.*
LIP-3, Continue Use of High Resolution Resistivity	*The Panel recommends continuing utilization of high resolution resistivity for leak detection outside of tanks. High resolution resistivity can detect a 5,000 to 10,000 gallon leak by utilizing existing dry-wells to measure soil resistivity. The technique has proved effective during recent waste retrieval activities.*
MCM-1, Install Surface Barrier Over SST Farms	*The Panel recommends design and implementation of a surface barrier to reduce recharge at the SSTs. Sources of water (leaking pipes, vaults, etc.) that could contribute to subsurface water deep percolation should also be identified and controlled. New control/barrier measures should be prioritized based on the risk associated with past and/or future releases at each tank farm.*
SI-5,Test Dome Concrete and Rebar ‘Plugs’	*Current plans call for the cutting of holes in the SST domes to facilitate the use of retrieval equipment. The Panel recommends the following tests on concrete and rebar ‘plugs’ removed from domes during cutting: (1) concrete compression and bend tests; and (2) rebar diameter measurement and tensile tests. These tests will provide an opportunity to obtain data on the condition of the dome concrete and rebar.*

SI-6, Develop Engineering Mechanics Document	*The Panel recommends the development and up-to-date maintenance of a living document containing the best current understanding of engineering mechanics properties of each tank. Such a document is an important reference in understanding both the current and future structural integrity of the SSTs and will be useful in defining input information for future tank evaluations.*
LD-3, Examine "non-compliant" wastes at 25°C	*The Panel recommends selected "non-compliant" SST waste simulants be examined at 25°C. "Non-compliant" wastes are those that fail to meet specific temperature, nitrite, nitrate, and hydroxide concentration criteria. The examinations will provide information on the propensity for pitting, cracking, and corrosion at the liquid-air interface (LAI) or corrosion of the liner in the vapor space. This testing should be coordinated with the double-shell tank (DST) testing program.*
LD-5, Determine Ammonia Corrosion Control Concentration	*Ammonia in sufficient concentrations has the potential to inhibit liner corrosion. The Panel recommends laboratory testing to determine the concentration of ammonia required to control corrosion in the liquid phases of the solid and supernatant layers, at the LAI, and on the exposed liner in the vapor spaces. This testing should be coordinated with the DST testing program.*
LD-6, Assess SST Waste Compositional Variation	*The Panel recommends determining whether the compositional variation in the solid layers of the SSTs deviates from the general SST and DST programmatic assumptions about composition. If so, testing work may need to be performed to evaluate the propensity for stress corrosion cracking (SCC) and corrosion.*
LIP-8, Assess the Feasibility of Testing for Ionic Conductivity Between Inside and Outside of SSTs	*The Panel recommends performing experiments to assess the viability of testing ionic conductivity between the inside and outside of the SSTs. An ionic path between the inside and outside of the SSTs could be indicative of cracks through the liner and concrete. If techniques can reliably measure such ionic conductivity, it would be useful in demonstrating whether breaches exist in SSTs.*
LIP-5, Evaluate Sludge and Saltcake Liquid Leak Rates	*The Panel recommends evaluating liquid leak rate assessments of sludge and saltcake from the Savannah River Site to determine if the results are applicable to SSTs. There is currently no evidence that liquid is leaking from the interim stabilized (retrieved) tanks that contain supernatant, sludge or salt cake. Nor is there evidence that new stress corrosion cracks have developed since the tanks were stabilized. Information as to whether liquid would leak out of sludge or salt cake through stress corrosion cracks is important when considering continued use of the SSTs.*