Development and Implementation of Regulator Approved Sampling and Analysis and Quality Assurance Program Plans for Underground Radioactive Waste Tank Residuals Characterization at the Savannah River Site – 14412

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ABSTRACT

The radioactive waste tank closure program at Savannah River Site (SRS) required the development and adoption of specialized documents and practices for residual material characterizations to support tank closure decisions. The Liquid Waste Tank Residuals Sampling and Analysis Program Plan (LWTRSAPP) and Quality Assurance Program Plan (LWTRS-QAPP) were developed in conjunction with the United States Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (SCDHEC) to establish a consistent and defensible process to representatively sample and characterize the material(s) that will remain in a waste tank after it is operationally closed. The LWTRSAPP and LWTRS-QAPP are intended to govern waste tank residual material characterizations for the lifetime of the tank farm closure project.

To obtain LWTRSAPP and LWTRS-QAPP approval, an integrated team including members from the United States Department of Energy (DOE), Savannah River Remediation (SRR), Savannah River Nuclear Solutions (SRNS), and Savannah River National Laboratory (SRNL) worked directly with the SCDHEC and EPA representatives to ensure regulatory requirements were understood, addressed or modified as necessary, and accepted by all parties. The characterization approach was designed to be flexible to cope with tank-specific sampling and analysis situations and to provide for regulatory involvement in the characterization process. The same integrated group approach is being used to develop and standardize additional closure documents and processes. Communication between all parties and the commitment to accept and implement the new programmatic requirements were vital to the approval of the documents.

INTRODUCTION

The Savannah River Site (SRS) is an 800 square-kilometer, federally-owned facility located in southwest South Carolina on the banks of the Savannah River (Figure 1). The site is managed by DOE and is operated today by a number of prime contractors. Since the early 1950's, the primary mission of SRS had been to produce nuclear materials for use in

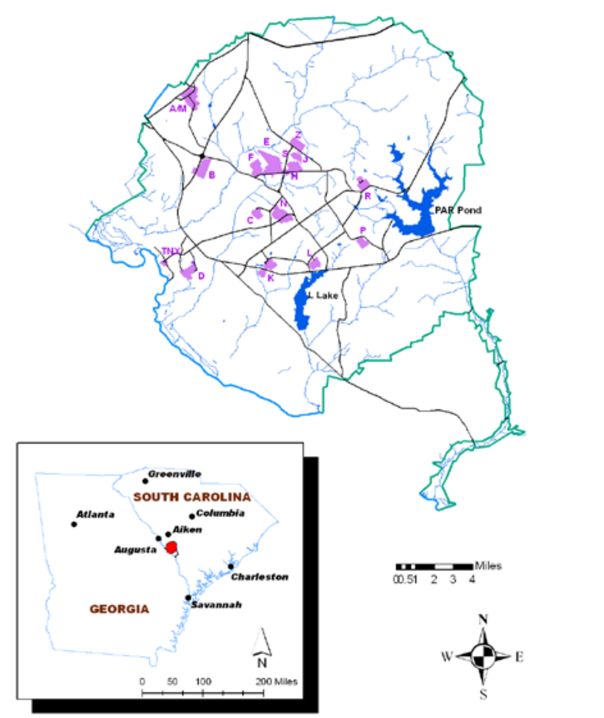


Fig. 1. The Savannah River Site.

national defense and deep space missions. A legacy of the SRS mission was the generation of liquid radioactive waste from chemical separations processes in both F and H Areas. Since the beginning of SRS operations, an integrated waste management 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 F-Area Tank Farm (FTF) and H-Area Tank Farm (HTF) located in F and H Area respectively, which are near the center of the site. Plutonium, uranium, and other radionuclides were extracted from irradiated fuel and target assemblies at the F- and H-Chemical Separations Facilities, called “canyons.” The resultant liquid radioactive wastes were transferred to the FTF and HTF for storage, treatment, and disposition. The tank farms include waste tanks, evaporators, transfer line systems and other ancillary structures and equipment. FTF contains 22 waste tanks (Figure 2) and HTF contains 29 waste tanks (Figure 3) that range in storage capacity from 750,000 to 1,300,000 gallons. All 51 of the waste tank liners were constructed of carbon steel following one of four principal designs designated as Type I, II, III/IIIA, and IV (Figure 4). Each tank type has varying degrees of secondary containment, roof support columns, cooling coils, and interior access points, all of which present challenges for waste removal and sampling. In the FTF, six waste tanks have been operationally closed (Tanks 5, 6, and 17 through 20). Others are in various stages of bulk waste removal, cleaning, residuals characterization, or physical isolation in preparation for operational closure.

Fig. 2. SRS F-Tank Farm.

Fig. 3. SRS H-Tank Farm.

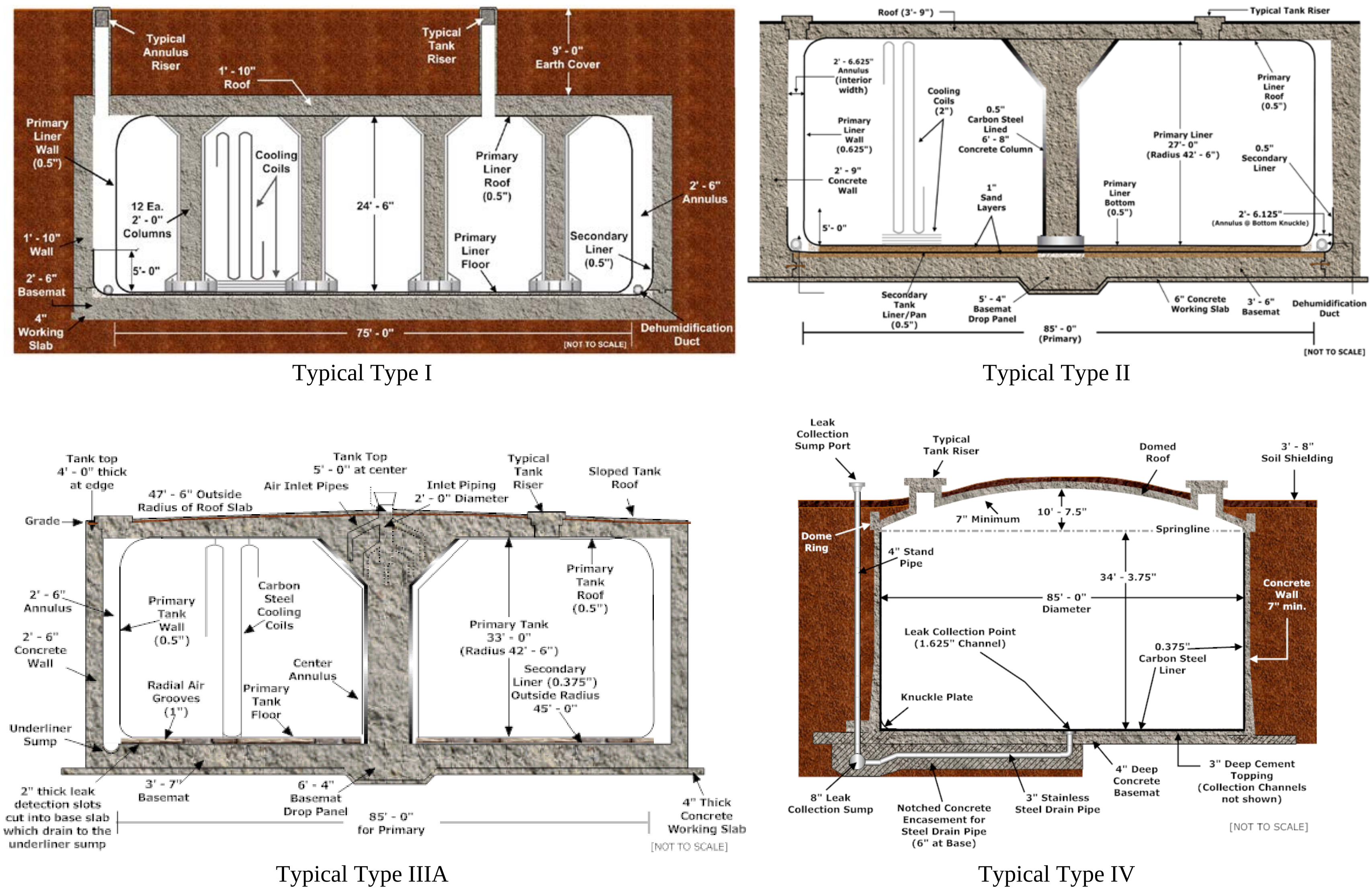


Fig. 4. Type I through IV Waste Tank Designs Used at SRS.

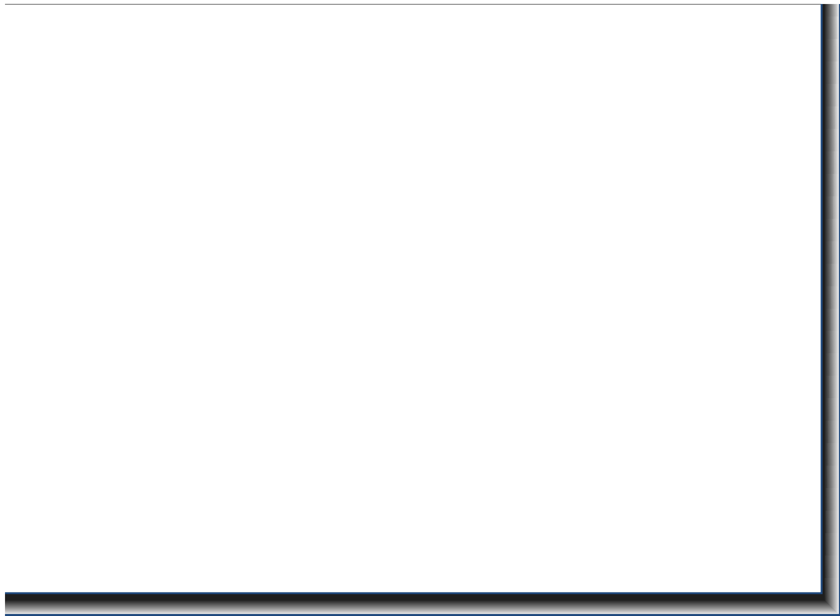
Since both F Canyon and H Canyon separation methods used nitric acid-based processes to recover the nuclear materials, the waste had to be conditioned to a very alkaline solution prior to transfer to the tank farms. This conditioning was performed through the addition of sodium hydroxide which resulted in the precipitation of metal oxides and metal hydroxides that ultimately settled to the bottom of the receptor waste tanks. This layer of settled insoluble solids is typically referred to as “sludge.” The liquid solution sitting above the sludge layer is typically referred to as supernatant or “supernate.”

Sludge not removed during waste tank cleaning efforts, scale and activation products on the tank liner wall and cooling coil surfaces, and any material present in the tank annular space are referred to as “residuals.” Characterization of the residuals is required to develop the waste tank “inventory” of chemical and radionuclide species. Residuals sampling, and the inventory that the characterization data support, are used as input to complex computational models to assess the long-term fate and transport of the chemical and radiological constituents in the environment and to support waste tank closure decisions. This paper focuses on the development of the sampling and analysis programs for waste tank residuals characterization.

PROGRAM DEVELOPMENT

The residual materials in the SRS underground liquid waste tanks have been difficult to sample and very challenging to analyze. Lessons learned from the residuals sampling and characterization efforts at Tanks 18 and 19 in 2009 and 2010, showed that a new characterization approach would be necessary for the tank closure program to succeed in a timely, cost-effective manner. It was also recognized that formalization and standardization of the program would save time and effort, accelerate the closure process, and ensure long-term program continuity. However as the program was developed it became apparent that a high degree of interaction, education, acceptance and development of new requirements and controls by all parties would be necessary for full program implementation. New programs and processes were developed, using existing procedures if possible, and modified as necessary following initial implementation. The total scope of the waste tank closure program was also evaluated to ensure information and documentation necessary to support the eventual closure of the FTF and HTF would be identified and compiled. In order to maintain the aggressive schedule for the new set of tank closures, the LWTRSAPP was developed first, followed by the LWTRS-QAPP. [1, 2] The LWTRSAPP presents the general methodology and guidance for the sampling and analysis of the residual materials. The LWTRS-QAPP establishes the specific quality assurance/quality control (QA/QC) requirements necessary for program application across the SRS organization and to produce defensible data to meet the LWTRSAPP Data Quality Objectives (DQOs). Together the documents establish the framework and program protocols necessary to characterize the residual materials that will remain in the waste tanks and ensure continuity over the life of the tank farm closure project.

Initially the scope of the LWTRSAPP was defined and the SRS organizations involved in the implementation were identified so they could be actively engaged in the program development. As shown in Figure 5, the LWTRSAPP scope begins when SCDHEC, EPA and DOE concur that waste removal efforts in a tank may cease and the sampling and analysis phase may begin. The LWTRSAPP scope ends after the Data Quality Assessment (DQA) determines the generated data quantity and quality is sufficient for use to support the tank closure decisions (Figure 5). The SRS organizations involved with the LWTRSAPP and LWTRS-QAPP development and implementation are shown on Figure 6. The SCDHEC and EPA were engaged early in the LWTRSAPP and LWTRS-QAPP development for feedback and approval as discussed below.



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

Fig 5. The General Waste Tank Residuals Characterization Process.

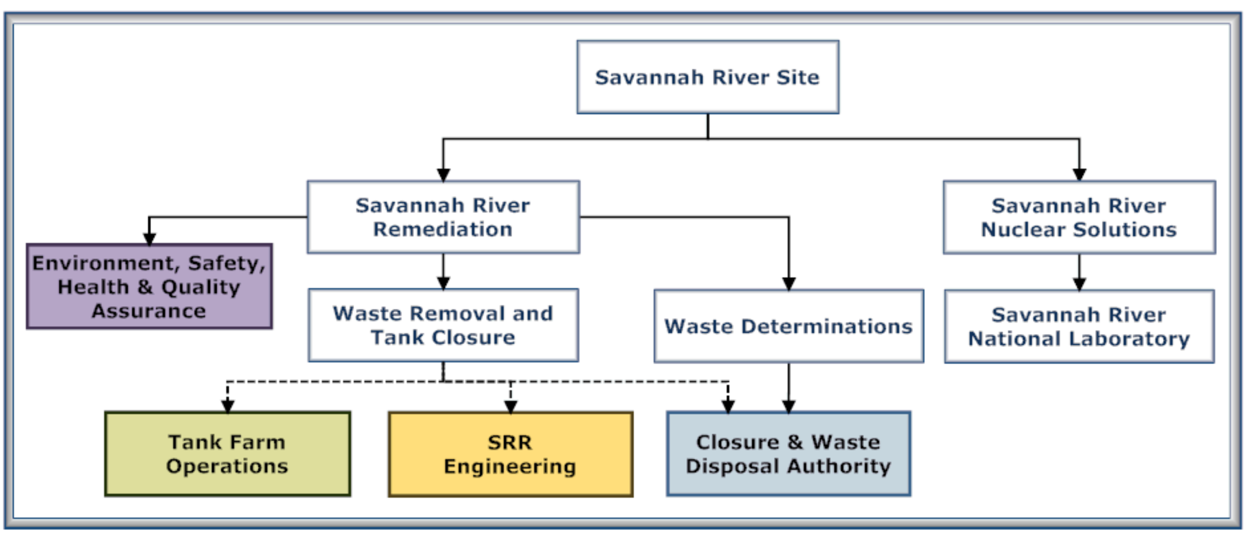


Fig. 6. Organizational Structure for LWTRSAPP and LWTRS-QAPP Implementation.

Early on, the program DQOs were developed in conjunction with the new sampling approach. The DQOs developed for the waste tank closure program are to:

> *Provide waste tank residuals material characterization (concentrations) that enable residuals material inventory determinations to support tank closure decisions.*

In considering possible sampling approaches, accessibility restrictions, the possible residual materials distribution(s) and physical condition(s) in a waste tank, analysis times and cost, worker exposure, and the overall project schedule and budget were evaluated. Stratified random sampling with volume-proportional compositing was chosen as the most appropriate approach to control sample error, incorporate uncertainty in the residual volume determination in the composting and meet the characterization objective of determining the average concentrations in the residuals. [1, 3] Discussions continued within SRR on possible additional costs and schedule impacts that might be required for LWTRSAPP implementation. When all parties agreed, the sampling approach was presented to SCDHEC and EPA in May 2011.

SCDHEC accepted the sampling approach, but delayed LWTRSAPP approval until the LWTRS-QAPP was submitted. It was also stipulated that the LWTRS-QAPP follow the requirements of the SCDHEC Quality Assurance Program Plan guidance for large projects. SRR worked diligently with SCDHEC personnel to follow the guidance as much as possible, but also to recognize that some aspects, like sample holding times or preservation, were simply not possible to implement due to handling requirements for highly radioactive materials. Other requirements entailed adaptation and implementation of:

- A residuals material mapper training and qualification program,
- A program-specific Chain-of-Custody procedure,
- Scheduled and documented QA/QC oversight; particularly on new processes,
- Data validation protocols and checklists, and
- A records filing, tracking, and retention program.

SRNL was actively engaged to institutionalize a documentation process specific to the needs and requirements of the residuals characterization program. Third-party experts were also engaged to oversee the development of data validation protocols and checklists tailored to the unique nature of the residual material analyses.

The LWTRS-QAPP, Revision 0, and LWTRSAPP, Revision 1, were submitted to SCDHEC and EPA in February 2012 and were both approved in early March 2012. The documents were revised in 2013 to incorporate additional program improvements and lessons learned during the sampling and analysis of Tanks 5 and 6. [1, 2]

SAMPLING AND ANALYSIS PROGRAM PROCESS

A high degree of involvement and consultation continues with DOE, SCDHEC, and EPA to inform and improve the waste tank closure program and deal with the idiosyncrasies of individual waste tank samplings.

The sample planning process for a specific tank begins with the preliminary residuals volume determination, and associated material distribution map. As mentioned earlier, a training and qualification program had to be established to specifically train and mentor the residual material mappers for this process. Because of the interior interferences in most waste tanks, conventional 3-D visual or radar mapping approaches cannot be used to estimate the remaining residual material volume or distribution. SRR Engineering also prepares a sampling and inspection accessibility evaluation of the tank interior that details risers that are available, not available, or could be accessed with additional effort. These factors are used to start the sampling and analysis planning process (Figure 7). A Sample Location Determination Report (SLDR) is produced at the end of the planning process to document the reasoning and sample locations necessary to characterize the residuals to meet the DQOs.

Fig. 7. Sampling and Analysis Planning Process.

Because of differences in the waste receipt history between the FTF and HTF, and between individual tanks, tank-specific radionuclide and chemical analyte lists are developed. The SLDR and analyte lists developed for each tank are typically presented to SCDHEC and EPA in a meeting in advance of waste tank sampling. Any comments or concerns are discussed and incorporated as necessary and a Tank-Specific Sampling and Analysis Plan (TSAP) is generated. The TSAP is used to generate a Technical Task Request (TTR) which is the contract vehicle for sample analysis with SRNL. SRNL generates a Task Technical Quality Assurance Plan (TTQAP) for laboratory internal QA and QC. The TSAP and TTQAP refer back to the requirements and procedures specified in the LWTRSAPP and LWTRS-QAPP as necessary. The general documents prepared are shown on Figure 8.

At the conclusion of a waste tank characterization, the Sample Analysis Report and associated statistical data evaluation, and when applicable, data validation results, are evaluated in a DQA. If the data are shown to be adequate and acceptable to meet the DQOs, it is used in the inventory determination and subsequent tank closure decisions and documents (Figure 8).

Fig. 8. Programmatic and Tank-Specific Documents and Steps in the Waste Tank Residuals Characterization Process.

CONCLUSIONS

The residual materials in the SRS underground liquid waste tanks are difficult to sample and very difficult to analyze. Defining a reasonable sampling and analysis program acceptable to all parties would not have been possible without the close interactions between SRNL, SRNS, SRR, DOE, and the regulators (EPA and SCDHEC). At times, specific meetings were required to address and educate the parties involved on the benefit or impossibility of what would be routine on a typical environmental characterization project. The willingness to accept new ideas, modify existing programs and processes, and implement the programs was fundamental to the acceptance and approval of the LWTRSAPP and LWTRS-QAPP. The close interactions and program modifications as more lessons are learned will continue through the life of the waste tank closure project.

REFERENCES

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