Integration of Performance Assessments and 3116 Basis Documents within the Savannah River Site Liquid Waste Facilities - 15375

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ABSTRACT

The end of the Cold War has left a legacy of over 136 million liters (36 million gallons) of radioactive waste in the aging waste tanks at the Department of Energy's Savannah River Site (SRS). A robust program is in place to remove waste from these tanks, treat the waste to separate it into a relatively small volume of high-level waste and a large volume of low-level waste, and to actively dispose of the low-level waste on-site. This process allows the US Department of Energy (DOE) to move forward with closure of the cleaned waste tanks and associated ancillary structures. To support performance-based, risk decision making for closure and disposal activities, three individual performance assessments (PAs) have been developed – Saltstone Disposal Facility, F-Tank Farm and H-Tank Farm. In addition, three Waste Determinations (WDs) have been made by the Secretary of Energy, in consultation with the Nuclear Regulatory Commission (NRC), under the authority of Section 3116 of the *Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005* (NDAA Section 3116). To support these waste determination decisions, individual "3116 Basis Documents" were developed that describe the assumptions and conditions under which the criteria outlined in NDAA Section 3116 are met.

The development of each of the PAs represented a long and arduous effort that involved the development of both deterministic and probabilistic conceptual models of the facilities, the development of assumptions and associated ranges, uncertainty and sensitivity analyses, model data collection and analyses, writing of the actual performance assessment, internal and external peer reviews, and ultimately approval by DOE. Similarly, the development of the 3116 Basis Documents represents similar time and financial commitments. At the end of these efforts, after years of preparation and millions of dollars in investment, we have thousands of pages of highly technical text, tables of data and hundreds of graphs and charts all contained in a series of thick binders that fit neatly on the shelf of a bookcase. We were done – right? Actually, we were just getting started.

Performance Assessments and 3116 Basis Documents are living documents that shape day-to-day and long-term decision making in the operation of a low-level waste disposal facility (e.g., Saltstone Disposal Facility) or in area closure activities (e.g., F-Tank Farm or H-Tank Farm). Although these documents do not contain specifically described requirements per se, they do utilize specific assumptions that, if changed significantly, could result in no longer being able to demonstrate that there is reasonable assurance that the required performance objectives or the criteria from NDAA Section 3116 can be met. Savannah River Remediation LLC (SRR), the contractor responsible for Liquid Waste operations at SRS, has not only developed the PAs and 3116 Basis Documents to support this work and shepherded these documents through the DOE approval process, but has also developed the processes and procedures to ensure the successful implementation and integration of these documents into day-to-day decision making within the associated facilities. This paper describes these processes, including the Unreviewed Waste Management Question process and the PA Maintenance process, and provides specific examples of their successful implementation.

INTRODUCTION

The Savannah River Site (SRS) is a 800 square-kilometer (310 square-mile), federally-owned facility located in southwest South Carolina on the banks of the Savannah River (Figure 1). The site is managed by the US Department of Energy (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 national defense and deep space missions. As many as five production reactors were operational at SRS from the mid-1950's through the late 1980's. Two large chemical separations facilities – known as the F-Canyon Facility and the H-Canyon Facility – also began operations in the mid-1950's. The F-Canyon Facility primary dissolved target assemblies to recover weapons grade plutonium. The H-Canyon Facility primarily has reprocessed used reactor fuel to recover highly enriched uranium and continues to operate today. Throughout the decades of their operations, the SRS canyon facilities have generated large quantities of radioactive liquid waste and, today, over 136 million liters (36 million gallons) remain. The two tank farms that receive this waste, referred to as F-Tank Farm (FTF) and H-Tank Farm (HTF), consist of a total of 51 waste tanks ranging in storage capacity of 2,800,000 liters (750,000 gallons) to 4,900,000 liters (1,300,000 gallons). FTF contains 22 waste tanks (Figure 2) and HTF contains 29 waste tanks (Figure 3).

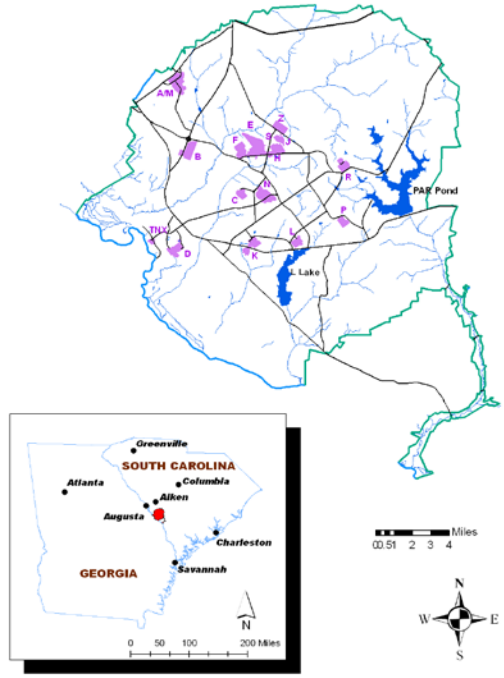

Fig. 1. The Savannah River Site

Fig. 2. SRS F-Tank Farm

Fig. 3. SRS H-Tank Farm

All 51 of the SRS waste tanks were constructed of carbon steel. Since the separation processes in both F Canyon and H Canyon utilized nitric acid-based flowsheets to recover the nuclear materials, the waste generated from these operations had to be conditioned to a very alkaline solution prior to transfer to the tank farms. This conditioning was accomplished through the addition of sodium hydroxide to the waste.

This addition results in the precipitation of metal oxides and metal hydroxides that ultimately settle to the bottom of the waste tanks. These settled insoluble solids are typically referred to as “sludge.”

The liquid salt solution sitting above this sludge layer, typically referred to as supernate, is then decanted out of the waste tanks and processed through large evaporator systems. Through the use of these evaporator systems, this relative dilute salt solution is concentrated into two additional waste types referred to as “saltcake” and “concentrated supernate.” The saltcake forms as the concentrated solutions from the evaporator systems cool, resulting in the precipitation of salt crystals. The liquid portion that remains is then recycled through the evaporator system to maximize the quantity of water that can be driven from the solution. The concentrated supernate is a very viscous solution that primarily consists of sodium hydroxide. The breakdown of waste within the SRS Liquid Waste System, as of 9/30/2014, is reflected in Figure 4.

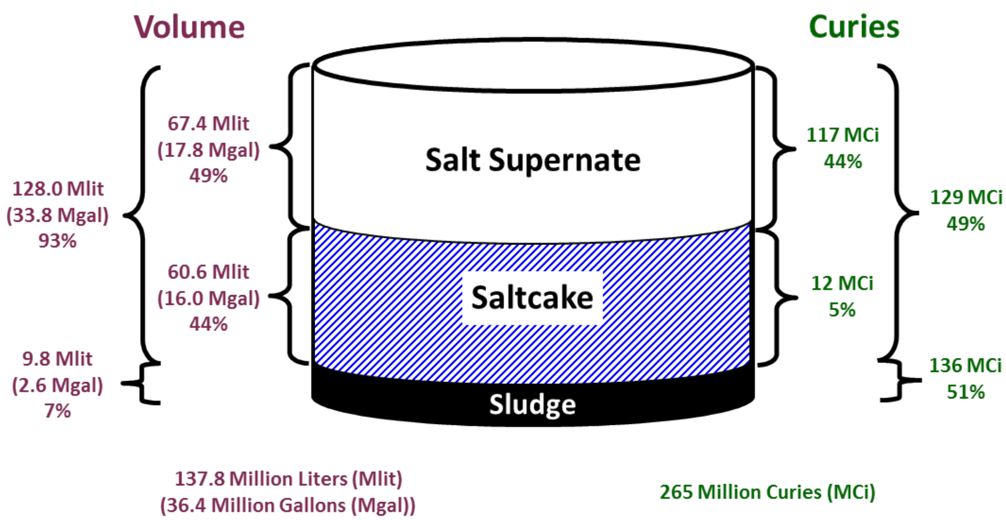

Fig. 4. Liquid Waste System Inventory as of 9/30/2014

The ultimate goal of DOE and the SRS Liquid Waste contractor, Savannah River Remediation LLC (SRR), is to safely remove and pretreat the tank waste to separate this waste into a high-volume, low-level waste fraction and a low-volume, high-level waste fraction, dispose of the low-level waste fraction in the Saltstone Disposal Facility (SDF) at SRS, vitrify the high-level waste fraction in preparation for eventual disposal in a deep geological repository, and stabilize and close the cleaned waste tanks and associated ancillary structures. In support of this mission, waste treatment facilities for both sludge and salt waste have been designed, constructed and are actively treating SRS tank waste. The SRS Liquid Waste System flowsheet is shown in Figure 5.

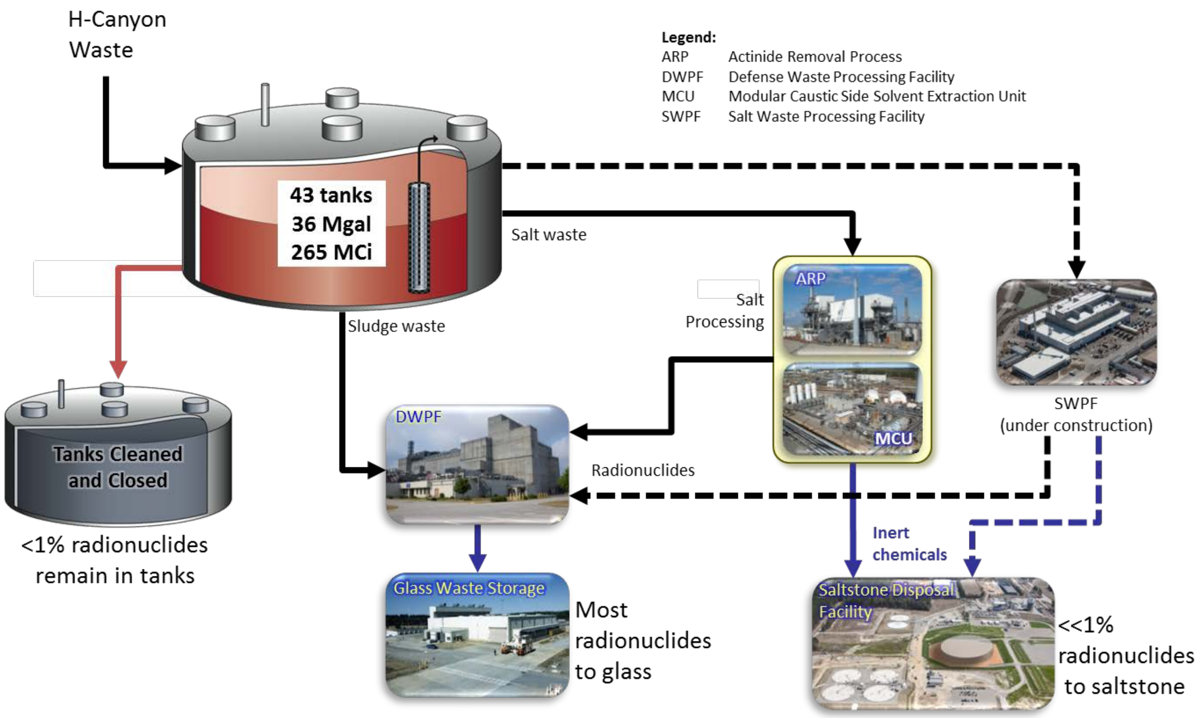

Fig. 5. SRS Liquid Waste System Flowsheet

REGULATORY STRUCTURE

Per the Atomic Energy Act of 1954, as amended, DOE is responsible for regulating defense-related radioactive waste including the tank waste at SRS. DOE regulates its operations through a series of Orders with associated Manual and Guidance documents. DOE Order 435.1, *Radioactive Waste Management*, and the associated DOE Manual 435.1-1, *Radioactive Waste Management Manual*, and DOE G 435.1-1, *Implementation Guide for use with DOE M 435.1*-1, specifically describe the requirements associated with the closure of high-level waste facilities and the design, operation and closure of low-level waste disposal facilities. DOE M 435.1-1, Chapter IV contains performance objectives that must be demonstrated for a low-level waste disposal facility. These performance objectives are directly applicable to the SDF at SRS (i.e., DOE must validate that the planned disposal actions for the life of the SDF will meet the performance objectives mandated in DOE M 435.1-1). DOE M 435.1-1, Chapter II describes the requirements for the management of high-level waste facilities including the closure of such facilities. The operation and closure of FTF and HTF at SRS are governed by these requirements, including processes for managing waste incidental to reprocessing (WIR), such as residuals remaining in the waste tanks at time of closure, as low-level waste. The requirements within DOE M 435.1-1, Chapter II, specifically direct that the performance objectives prescribed in Chapter IV for low-level waste disposal facilities must be demonstrated for facilities that formerly handled high-level waste, such as FTF and HTF.

Shortly after the DOE Order 435.1 was issued, the National Resources Defense Council (NRDC), et al., challenged the Department over the WIR provisions in Federal Court, stating that, given the specific wording in the Nuclear Waste Policy Act, DOE could not unilaterally “reclassify” high-level waste (HLW) as low-level waste (LLW), and that any waste that was HLW must remain in that classification. In 2003 in District Court, Chief Judge B. Lynn Winmill ruled that: (1) DOE did not have discretion to dispose of defense high-level radioactive waste somewhere other than repository established under Nuclear Waste Policy Act, and (2) that the order conflicted with the Act and thus was invalid. In

November 2004, the 9th Circuit Court of Appeals reversed the earlier ruling on the basis that the lawsuit was not "ripe" as DOE had never tried to act on the WIR Evaluation provisions and, in 2006, the case was formally dismissed.

Following Judge Winmill's initial ruling, DOE approached Congress for legislative relief. Led by Senator Lindsey Graham of South Carolina, the *Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005* (NDAA), included specific provisions that give the DOE this specific authority. Section 3116 of the NDAA provides the process by which DOE can manage both residuals remaining in cleaned tanks and lower activity waste as LLW or transuranic waste, provided the Secretary of Energy, in consultation with the Nuclear Regulatory Commission, makes the determination that DOE has demonstrated that: 1) the waste does not have unique characteristics that would require it be disposed of in a deep geological repository; 2) the highly radioactive radionuclides have been removed to the maximum extent practical; 3) it can be demonstrated that the disposal actions will be in compliance with the performance objectives of Title 10, Code of Federal Regulations Part 61, Subpart C (10CFR61); and 4) that the disposal actions will be pursuant to a state-approved closure plan or state-approved permit. A final requirement is that, if the waste being disposed of exceeds the Class C concentration limits associated with 10 CFR 61.55, then DOE must consult with the NRC on the associated disposal plans.

NDAA SECTION 3116

DOE has issued four Waste Determinations (WD) under Section 3116; three are associated with SRS and a fourth is associated with the tanks containing legacy waste from reprocessing activities at the Idaho Nuclear Technology and Engineering Center (formerly known as the Idaho Chemical Processing Plant) at the Idaho National Laboratory site. The SRS Salt Waste Disposal WD was issued in 2006 and allows for the chemically separated LLW fraction of the salt waste to be disposed of on site at the SDF. The LLW salt solution is mixed with dry cementitious materials and transferred into large disposal units to form a non-hazardous waste form called saltstone. The FTF WD was issued in 2012 and supports that the residuals remaining in the cleaned tanks in the FTF can be managed as a LLW. Once waste removal activities are completed on the tanks and the regulatory approval process is successfully concluded, these large tanks are filled with grout (a cement-like mixture with engineered features such as enhanced flowability, minimal bleedwater generation and targeted chemical properties) to stabilize the tanks. These tanks are as large as 4.9 million liters (1.3 million gallons) in volume and the grout serves as a barrier to infiltrating water over time, chemically conditions infiltrating water to minimize contaminant transport, and ensures the tank structures do not collapse over time. The HTF WD was recently issued in December 2014 and mirrors the FTF WD for the residuals remaining in the cleaned tanks in HTF.

To inform the Secretary of Energy's decision to issue a NDAA Section 3116 WD, an extensive collection of information is developed and packaged for review and consideration. DOE has established the protocol of creating a 3116 Basis Document that supports each WD. These Basis Documents provide background information on facilities and processes impacted by the specific WD, discuss the criteria of the NDAA Section 3116 legislation, and provide the bases used to validate that each criteria is currently met and will continue to be met throughout the active operations of the disposal facilities or the closure activities for the cleaned waste tanks, and during the post closure time period. This post closure time period is typically referred to as the "Period of Compliance." DOE M 435.1-1 mandates a post-closure Period of Compliance of 1,000 years. The Basis Documents further account for periods beyond the 1,000-year time standard to better understand the impacts and risks associated with the closure and disposal decisions.

RISK ASSESSMENT TOOLS

Ultimately, since disposal and closure activities result in radioactive material being left near surface and, given that future individuals could inadvertently stumble upon the material and not recognize the potential risk to human health and the environment, risk decisions today must be made that could potentially effect hypothetical individuals well into the distant future – thousands of years following site closure. The performance objectives established in the various applicable regulatory schemes were developed to minimize the risks to future generations. The assumptions that are used in demonstrating compliance with these regulatorily-mandated performance objectives are critical to making sound, risk-based decisions. For example, the NDAA Section 3116 requires that the performance objectives contained in 10CFR61, Subpart C must be demonstrated. Two of these performance objectives, 10CFR61.41 and 10CFR61.42, require a projection of doses to future hypothetical individuals.

The tool that is typically used to inform these risk decisions is a performance assessment (PA). PAs utilize complex computational models to better understand anticipated system behavior in the fate and transport of materials into the environment and to hypothetical human receptors over long periods of time, often for tens of thousands of years into the future. Typically, the output of these assessments is dose values that can then be compared against regulatory limits that have been established as performance objectives.

Selection of the assumptions that are used within the PA models is a critical element of PA development. There are typically a group of key assumptions that significantly influence the results. These key assumptions can be categorized into two groups: standard assumptions and site-specific assumptions. The standard assumptions include such things as the period of performance (e.g., 30 years, 1,000 years or 10,000 years) and the point of compliance (e.g., 100-meter buffer zone). Different regulatory agencies often require different values for these assumptions and require them to be used consistently for all PAs under their purview. If multiple agencies are involved in the review and acceptance of the PA results, the difference in the standard assumptions can result in costly expenditures related to defending assumptions or taking additional protective measures, especially if the use of the less conservative, best-estimate assumptions could result in the predicted results challenging the performance objectives.

Site-specific assumptions reflect the conditions unique to the facility being assessed such as the assumed degradation rates for barriers, the chemical properties of the pore water within the cementitious materials, or the physical and chemical properties of the surrounding soils. In addition, the methods of operation or cleaning and the final form or packaging of the waste or residuals are also critical site-specific assumptions. The greatest challenge in developing a PA is the selection of site-specific assumptions since each key assumption can have a significant effect on the outcome of the results. Because the results are then compared against a regulatory standard and risk decisions are then made based on the PA's results, the defense of these results, and more specifically the assumptions that led to these results, must be considered when initially scoping the PA and developing the assumptions. The true art of PA development lies in balancing the selection of the most probable parameter values based on the preponderance of the available data (i.e., best-estimate values) or selecting conservative values that are easily defended because they are, or are approaching, bounding values. The specific conditions of the respective site can drive these decisions. For example, at the DOE facility in Idaho, due to the materials of construction of the waste tanks present there (stainless steel with no significant internal cooling coil interferences) and the nature of the waste (maintained in an acidic solution), the remaining residuals in the tanks following cleaning were minimal. Because of this, as well as the environmental conditions at the Idaho site (arid climate with a deep water table), very conservative assumptions could be assumed throughout the system without challenging the dose-based performance objectives. Since the conditions associated with the SRS waste tanks are very different, the assumptions utilized in SRS Tank Farm PAs cannot be as conservative. Instead, the SRS Tank Farm PAs must use values that are, or conservatively approach, best-estimate values. A final but critical feature that must be considered in developing the site-specific assumptions is that these assumptions must be reflective of conditions that can and will be implemented in the operations of a low-level waste disposal facility or in the closure of a waste tank.

IMPLEMENTATION AND MAINTENANCE PROGRAMS

Once the WDs and the PAs for the specific facilities are developed, reviewed, approved and formally made part of the facilities' Radioactive Waste Management Basis, it is essential that they are "maintained." These documents cannot be checked off as complete and then forgotten about. As described above, the conclusion that it is safe to operate the disposal facility or close the cleaned tanks with the associated residuals can be directly traced back to the assumptions that form the foundation for both the WDs and the PAs. Understanding the content of these documents through training of the implementing organizations, up-to-date processes and procedures, and open, clear channels of communication between the operating organizations and the regulatory authority team (i.e., the experts in the 3116 Basis Documents and PAs) are essential facets of safe nuclear operations and an associated healthy Nuclear Safety Culture.

DOE M 435.1-1 requires the ongoing maintenance of all PAs. As described above, since PA results are, in part, based on data and assumptions that are uncertain due the utilization of projected conditions thousands of years into the future, a robust maintenance program is needed to continue to reduce uncertainty in the inputs and assumptions, ultimately providing greater confidence in the results of the analyses and in the long-term plans for public and environmental protection. Additionally, a disciplined process to address potential changes in disposal and/or closure operations (e.g., change in disposal unit design, new residual material characterization) is needed to ensure that the proposed changes or new information do not adversely affect conclusions reached using PA results. In support of these goals, SRR has developed the Liquid Waste (LW) PA Maintenance Program to confirm the continued adequacy of the LW PAs (i.e., SDF, FTF and HTF PAs) and to increase confidence over time in the results of these PAs. The elements of the LW PA Maintenance Program are:

- Testing and research;
- Monitoring;
- Unreviewed Waste Management Question (UWMQ) process;
- Special Analyses (SAs); and
- PA revisions.

SRR has focused considerable resources on ongoing testing and research since the mid-2000 time frame. The majority of this research supported the disposal of the low-level fraction of the salt waste in the SDF; however, past, ongoing and future work is also associated with grouted waste tank conditions. Figure 6 reproduces a figure from the *SRS Liquid Waste Facilities Performance Assessment Maintenance Program – FY2015 Implementation Plan* and summarizes the elements of the ongoing salt waste disposal testing.

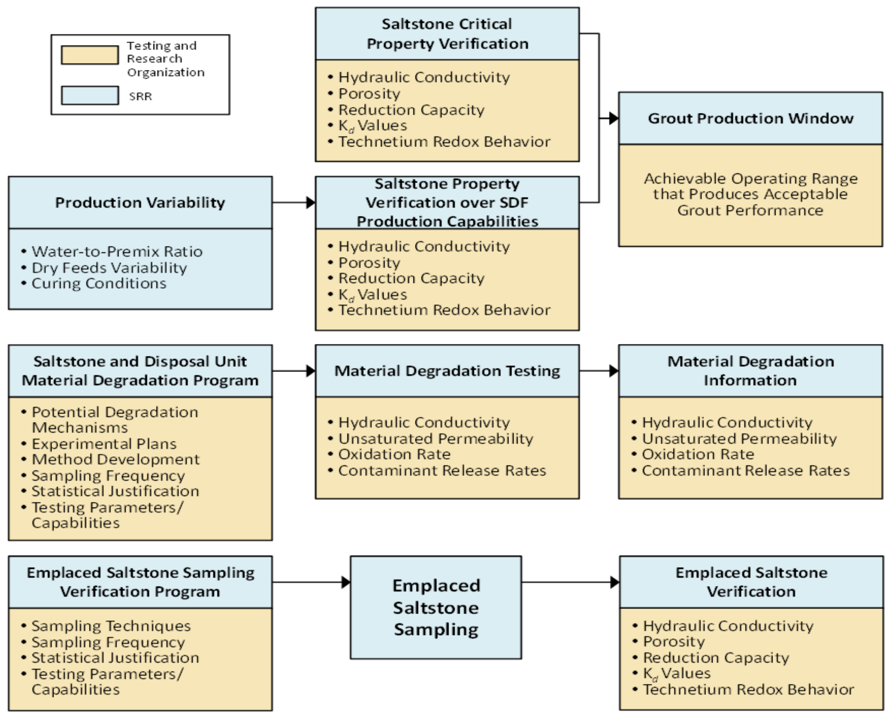

Fig. 6. Saltstone Research, Development, and Testing Program Elements

The Maintenance Program Implementation Plan provides further details on the work that has been performed, is ongoing or is planned as future work for each element of the program. An example of the detail contained in the Plan is shown below in Figure 7, another replica chart from the Plan.

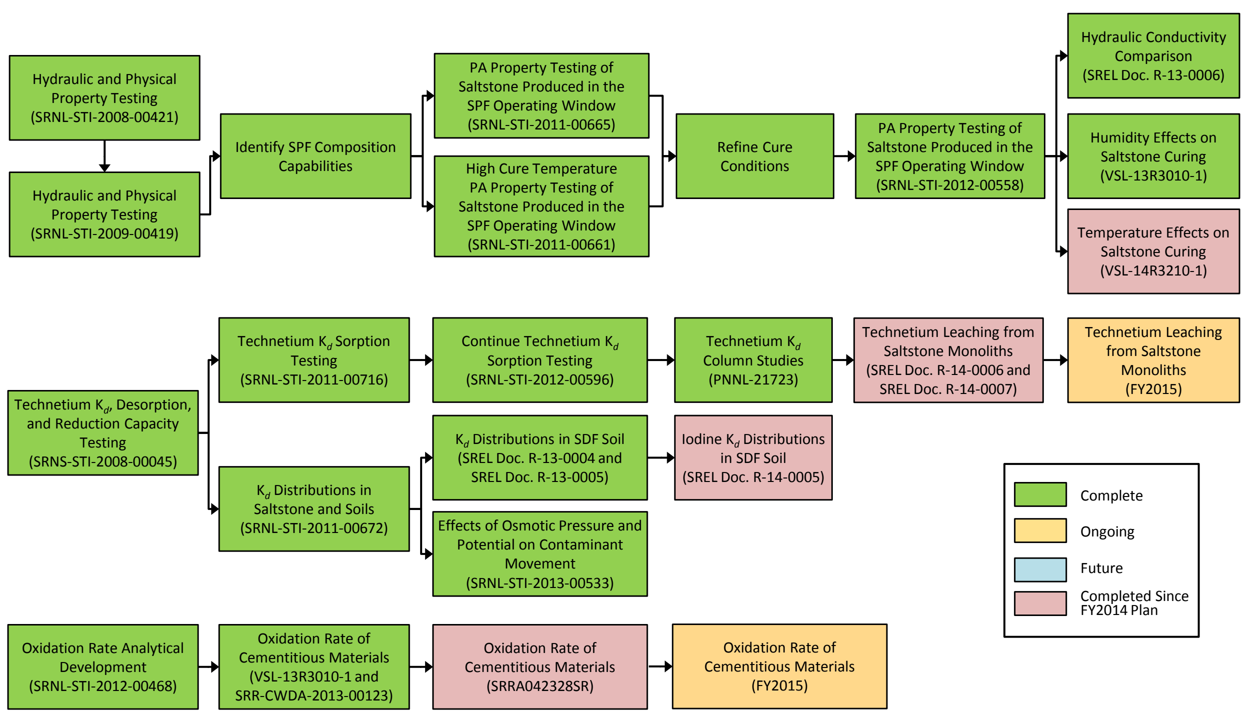

Fig. 7. Critical Property Testing

The maintenance program will continue in this manner until there is good confidence in all of the critical assumptions underpinning each of the three LW PAs. Once that level of confidence is reached, future research will be driven by the introduction of new information or changes in disposal/closure actions that may bring the applicability of a key assumption into question. The maintenance program then will transition to more of a monitoring role.

RECOGNIZING AND EVALUATING CHANGE

Another critical element of an effective process is recognizing and evaluating changes in the processes, programs or physical conditions in facilities, or new information received from any number of sources (e.g., the aforementioned research, development and testing programs). Formal processes must be institutionalized and key staff must participate in ongoing training to understand their responsibilities to evaluate potential changes or new information. To this end, SRR has developed a process known as the Unreviewed Waste Management Question (UWMQ). The UWMQ process was patterned from the Unreviewed Safety Question (USQ) process that was first developed within DOE to evaluate potential impacts to a facility's formal Safety Basis.

The UWMQ process ensures that "proposed activities" or "new information" at SRS (e.g., new waste streams, radionuclide inventories, facility design and operations) are formally reviewed to ensure the inputs, assumptions, results and conclusions of the following documents remain valid:

- The SDF, FTF and HTF PAs;
- The Salt Waste Disposal WD, the FTF WD and the HTF WD;
- SRS Composite Analysis (CA); and
- Any Special Analyses (SA) or previous UWMQ Evaluations associated with the PAs, WDs or SRS CA.

The SRS CA is a DOE M 435.1-1 mandated evaluation that looks at all sources of potential environmental contamination on sites that contain a low-level waste disposal facility to ensure that impacts at the site boundary are projected to remain below specific performance objectives. It is similar to a facility PA but, instead of being focused on a single facility at SRS, it is looking at the entire site. Special Analyses are addendums to an approved PA that evaluate specific new information. Two of the three LW PAs at SRS have associated SAs that evaluated new information after the PA was approved and implemented. For example, SAs were performed for the FTF PA once final residual characterization was performed for tanks that had been cleaned. The FTF PA originally assessed informed residual inventory assigned for each tank that had yet to be cleaned and characterized. Once final inventories of a cleaned tank are known, this new information is evaluated to ensure that it does not impact the original conclusions of the PA, WD or CA.

The UWMQ process implementation is formalized within an SRR Engineering procedure that clearly defines the scope and responsibilities for each impacted organization. The SRR Waste Disposal Authority (WDA) Department – the organization responsible for developing the 3116 Basis Documents and PAs, shepherding the documents through the approval process, and maintaining the documents and associated procedures – has developed a UWMQ Requirements Document (UWMQRD) that identifies critical screening criteria to protect the inputs and assumptions used to develop the PA and 3116 Basis Document associated with the SDF. A similar set of screening criteria has been established by WDA to support cleaned tank grouting operations. Trained and formally qualified facility personnel, typically Facility Engineers, are responsible for defining any proposed activity or new data through an established and facility-specific technical review process, and then performing initial screens using the UWMQRD or set of screening criteria for cleaned waste tanks. If the screening is deemed positive (i.e., there could be a possible impact), WDA then performs a formal UWMQ Evaluation. By requiring trained WDA staff to perform the Evaluation, the process ensures that the most knowledgeable individuals are engaged in the process. A flowchart of the process is shown in Figure 8.

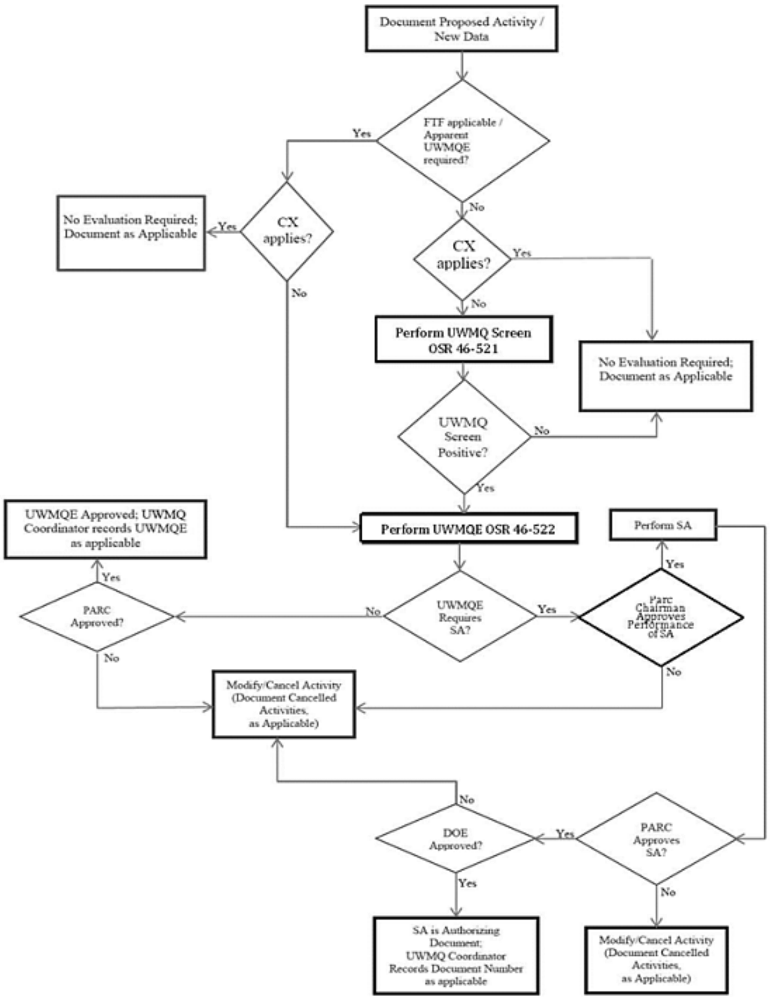

Fig. 8. UWMQ Process

Once the evaluations are complete, they are then taken through a formal approval process. SRR has established a Performance Assessment Review Committee (PARC) program to provide the approval authority. The PARCs are different for the SDF and the two SRS Tank Farms. Since the SDF is an operating low-level waste disposal facility, its PARC is chaired by the Facility Manager. Additional members of the PARC include the associated Operations Manager and Engineering Manager, and the WDA Manager. The PARC for the FTF and HTF is chaired by the SRR Closure Manager and also includes Operations, Engineering and WDA management as members, as well as the specific Project Manager responsible for grouting the specific tank in question. The selection of PARC membership in both cases ensures that knowledgeable managers, that have specific responsibilities related to the activity or information, are informed of the Evaluation and have approval authority to ensure first, that the information is correct and, second, that it is then implemented.

The final step in the process is to ensure that the UWMQE is formally part of the impacted facility's regulatory program. Once a UWMQE is approved by the PARC, it is placed in an electronic folder known as *SafetyNet* that contains all the pertinent documents that, together, form the bases that document how the facility fulfils its obligations related to regulatory and safety requirements. This process ensures these documents are institutionalized within the facility and that there is one place that a Facility Engineer can go when performing assessments on new information or proposed changes to the processes, or when performing assessments on the adequacy of the programs.

CONCLUSION

Facility-specific PAs and 3116 Basis Documents are living documents that shape day-to-day and long-term decision making in the operation of the SDF, or in tank closure activities occurring in the two SRS Tank Farm facilities. Although these documents do not contain specifically described requirements per se, they do utilize specific assumptions that, if changed significantly, could result in no longer being able to demonstrate that there is reasonable assurance that the required performance objectives or the criteria from NDAA Section 3116 can be met. SRR not only has developed the PAs and 3116 Basis Documents to support this work and shepherded these documents through the DOE approval process, but has also developed the processes and procedures to ensure the successful implementation and integration of these documents into day-to-day decision making within the associated facilities. The extensive PA Maintenance Program and the UWMQ process are two examples of programs that have been developed and utilized by SRR to meet these important objectives.

REFERENCES

1. NDAA 3116, *Public Law 108-375*, *Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005, Section 3116, Defense Site Acceleration Completion*, (2004).
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