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NRC Periodic Compliance Monitoring Report for U.S. Department of Energy Non-High-Level Waste Disposal Actions

Annual Report for Calendar Year 2009

Office of Federal and State Materials and
Environmental Management Programs

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ABSTRACT

This is the U.S. Nuclear Regulatory Commission (NRC) staff's report of its monitoring of U.S. Department of Energy (DOE) non-high-level waste disposal actions in calendar year 2009, in accordance with Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (the NDAA). Section 3116 of the NDAA requires that DOE consult with the NRC on its non-high-level waste determinations and plans and that the NRC, in coordination with the covered States of South Carolina and Idaho, monitor disposal actions that DOE takes to assess compliance with NRC regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," Subpart C, "Performance Objectives." The NRC has prepared this report in accordance with NUREG-1854, "NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations," issued August 2007 (NRC, 2007c).

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EXECUTIVE SUMMARY

The purpose of this report is to document the U.S. Nuclear Regulatory Commission (NRC) staff's monitoring of the U.S. Department of Energy (DOE) non-high-level waste disposal actions in calendar year (CY) 2009. The NRC monitors DOE disposal actions in covered States in accordance with Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (the NDAA). Section 3116 of the NDAA has two main subsections—one requires DOE to consult with the NRC on its non-high-level waste determinations and plans and the other requires the NRC, in coordination with the covered States of South Carolina and Idaho, to monitor the disposal actions that DOE takes to assess compliance with NRC regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," Subpart C, "Performance Objectives." This report is concerned primarily with the second of the two major parts of Section 3116, namely Section 3116(b). Appendix A to this report provides the complete text of Section 3116 of the NDAA. This report is the third of what the NRC anticipates will be an annual report during the early phases of its NDAA monitoring activities. The content of this report follows the guidance in Section 10.4.2 of NUREG-1854, "NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations," issued August 2007 (NRC, 2007c).

In CY 2007, the NRC completed two monitoring plans in accordance with the guidance in NUREG-1854 (NRC, 2007c). The monitoring plans cover DOE disposal actions at the Saltstone Facility at the Savannah River Site (SRS) in South Carolina and the Tank Farm Facility (TFF) at the Idaho Nuclear Technology and Engineering Center (INTEC) at the Idaho National Laboratory (INL). In each plan, the staff identified a hierarchy of elements defining the overall scope of monitoring at each site. The scope of monitoring was defined by those factors that were most uncertain or significant in the DOE analysis of whether the disposal of non-high-level waste meets NRC performance objectives, which are aimed at the protection of public health and safety. For the Saltstone Facility, the NRC staff identified eight "factors," which are important model assumptions or parameter values described in its December 2005 technical evaluation report. For each factor, the agency has one or more planned monitoring activities (i.e., specific tasks or actions). For Saltstone, 39 distinct monitoring activities exist to assess compliance with the performance objectives in 10 CFR Part 61, Subpart C. Similarly, for the INL INTEC TFF, the staff identified five key monitoring areas (which are analogous to the "factors" at Saltstone) from its October 2006 technical evaluation report and 31 separate monitoring activities. Monitoring activities can be either onsite observations of disposal activities or in-office reviews of documents.

In CY 2009, in accordance with the monitoring plans described above, the staff performed both technical reviews and onsite observation visits at the SRS Saltstone Facility. The staff performed only technical reviews at the INL INTEC TFF.

As the staff completed technical reviews and onsite observations, it followed up on open issues previously identified during monitoring activities and identified one new open issue. Open issues require additional follow-up by the NRC staff or additional information from DOE to address questions that the NRC staff raised regarding DOE disposal actions. For CY 2009, the NRC staff identified one open issue that arose during monitoring activities that requires additional follow-up by the NRC staff or additional information from DOE to address questions that the NRC staff has raised regarding the DOE disposal actions. Recommendations may address ways in which DOE can make progress on closing any open activities in the staff's monitoring plan; a monitoring area for which an open issue has been previously identified and closed and for which the NRC staff recommends further action to strengthen some aspect of the DOE disposal action; and monitoring areas that had no open issues or previously raised concerns, but for which the NRC staff recommends further improvements in DOE disposal actions.

In CY 2009, the staff's monitoring activities resulted in no findings of noncompliance. The staff continued to follow up on two open issues identified in CY 2007 and one new open issue identified in CY 2009. The staff has continued to monitor DOE progress on closing open issues in CY 2010. Tables 3 and 4 in the body of this report summarize the NRC staff's open issues and recommendations. The body of this report presents more information about the staff's observations. Appendix C contains the onsite observation reports.

This report assigns each monitoring activity described in the staff's monitoring plans for the SRS Saltstone Facility and the INL INTEC TFF a unique alphanumeric monitoring activity code for NRC staff tracking purposes. Tables B-1 and B-2 in Appendix B to this report list the monitoring activities and monitoring activity codes. The monitoring activity code contains information about the DOE site; the facility; the primary applicable 10 CFR Part 61, Subpart C, performance objective; the monitoring area; and the type of monitoring performed (i.e., onsite observation (O) or technical review (T)). The key for the monitoring activity codes is as follows:

Site	Facility	Performance Objective	Key Monitoring Area or Factor	Activity Number	Type of Activity
SRS- or INL-	SLT- or TFF-	41- 42- 43- 44-	01- 02- 03- RE[1] etc.	01- 02- 03- etc.	T or O

For example, the third monitoring activity listed in the NRC monitoring plan for the SRS Saltstone Facility (and thus the third entry in Table B-1 of this report) is coded "SRS-SLT-41-01-03-T." For tracking purposes, at least one monitoring activity code is cited for each open issue and recommendation described in this report.

Savannah River Site Saltstone Facility

In October 2007, the NRC staff observed that DOE had not generated hydraulic and chemical properties of saltstone grout over the range of compositions actually produced at the Saltstone Production Facility (SPF). The staff believes that additional data over a range of compositions will greatly reduce the uncertainty in estimating the future performance of the Saltstone Disposal Facility (SDF). The staff also observed that, at the end of a production run, DOE uses water to flush transfer lines between the SPF and SDF. The flush water is added directly to the SDF and may be blending with grout that has not yet set. The staff identified these issues as Open Issues 2007-1 and 2007-2, respectively, in NUREG-1911, "NRC Periodic Compliance Monitoring Report for U.S. Department of Energy Non-High-Level Waste Disposal Actions, Annual Report for Calendar Year 2007," issued August 2008 (NRC, 2008). In 2009, as in 2008, the staff observed that DOE is making progress in obtaining data that will provide additional support for assumptions that were used in DOE's performance assessment in support of the

1 RE stands for radiation protection or an environmental protection monitoring area not separately identified as either a key monitoring area or factor in the NRC's review of the DOE performance assessment.

SDF waste determination. However, because this information was still under review at the end of CY 2009, both Open Issue 2007-1 and Open Issue 2007-2 remain open.

In March 2009, the NRC staff observed that DOE provided insufficient support for assumptions made regarding the sorption capabilities of the saltstone wasteform with respect to K_d values assumed in the 2005 performance assessment and the reduction capabilities of technetium-99 in the saltstone wasteform.

In November 2009, the NRC staff began its review of the "2009 Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site," (updated PA) dated October 2009, and the associated documentation provided. This review is being performed in accordance with NRC's monitoring plan (NRC, 2007b) Section *3.1.9 Performance Assessment Process Review*. The NRC staff's review of the updated performance assessment will be document in a technical evaluation report (TER).

Idaho National Laboratory, Idaho Nuclear Technology and Engineering Center, Tank Farm Facility

The NRC staff identified no new recommendations or open issues in CY 2009 for the TFF.

Conclusion

Based on its observations, the NRC staff continues to conclude that reasonable assurance exists that the applicable criteria of the NDAA can be met if key assumptions made in the DOE waste determinations prove to be correct. In accordance with the requirements of the NDAA and consistent with the NRC's monitoring plans, the NRC staff will continue to monitor DOE disposal actions at SRS and INL. The staff expects the monitoring activities to be an iterative process, and several onsite observation visits and technical reviews of various reports, studies, and other documents may be necessary to obtain the information needed to close all of the current open issues, as well as issues that may be opened in the future.

ABBREVIATIONS

ADAMS	Agencywide Documents Access and Management System
ALARA	as low as reasonably achievable
CAP88-PC	Clean Air Act Assessment Package 1988
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CY	calendar year
DEQ	(Idaho) Department of Environmental Quality
DOE	U.S. Department of Energy
EM	environmental monitoring
HLW	high-level waste
HRR	highly radioactive radionuclide
ICRP	International Commission on Radiological Protection
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
KMA	key monitoring area
LFRG	Low-Level Waste Disposal Facility Federal Review Group
LLW	low-level waste
MDIFF	mesoscale diffusion air dispersion model
MEI	maximally exposed individual
mrem	millirem
mrem/yr	millirem per year
μSv	microsievert
μSv/yr	microsiever per year
NDAA	Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005
NRC	U.S. Nuclear Regulatory Commission
PA	performance assessment
SDF	Saltstone Disposal Facility
SPF	Saltstone Production Facility
SRPA	Snake River Plain Aquifer
SRS	Savannah River Site
TER	technical evaluation report
TFF	Tank Farm Facility

In this report, the first use of a word or phrase that is defined in the glossary is shown in *italics*.

1. INTRODUCTION

In October 2004, the U.S. Congress passed legislation that allows the Secretary of Energy to determine, in consultation with the U.S. Nuclear Regulatory Commission (NRC), whether radioactive waste resulting from the reprocessing of spent nuclear fuel is not high-level radioactive waste. The legislation in Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (the NDAA) requires that the U.S. Department of Energy (DOE) consult with the NRC on its non-high-level waste (HLW) determinations and plans and that the NRC, in coordination with the covered State, monitor DOE disposal actions to assess compliance with NRC regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," Subpart C, "Performance Objectives." The covered States under Section 3116 of the NDAA are South Carolina and Idaho.

Under the NDAA, DOE will identify specific inventories of radioactive waste and associated facilities and equipment (e.g., tanks, piping, disposal cells) that are candidates for non-HLW decisions. The Secretary's decision is based on whether the residual radioactive waste meets several criteria in Section 3116 of the NDAA. For example, the subject of a Secretary's decision may be residual radioactive waste remaining in an HLW storage tank after the *highly radioactive radionuclides* (HRR) have been removed to the maximum extent practicable. Appendix A to this report provides the full text of Section 3116 of the NDAA, including the criteria.

To support the Secretary's decision, DOE prepares a document that describes its basis for a determination under Section 3116 of the NDAA. Called a *waste determination*, this document describes the DOE analysis of whether a particular type of waste meets the NDAA criteria. As described in NUREG-1854, "NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations," issued August 2007 (NRC, 2007c), the NRC staff consults with DOE on the draft waste determination and prepares a technical evaluation report (TER) that documents the NRC staff's evaluation. If the Secretary decides that all of the Section 3116 criteria are met, the Secretary may make a non-HLW determination, and DOE may publish a final waste determination.

After the Secretary's determination, the NRC staff will, in coordination with the covered State and as described in NUREG-1854 (NRC, 2007c), prepare a written plan to monitor DOE's disposal actions for the purpose of assessing compliance with the *performance objectives* established in 10 CFR Part 61, Subpart C. Because NRC monitoring is risk informed and performance based, it focuses on assumptions, parameters, and features that are expected to have either a large influence on the performance demonstration or relatively large uncertainties, or both. Table 1 presents the performance objectives from 10 CFR Part 61, Subpart C.

Since the NDAA was enacted in 2004, DOE has completed two waste determinations in consultation with the NRC staff. The first, in January 2006, was the waste determination for salt waste disposal at the Savannah River Site (SRS) in South Carolina (DOE, 2006a). DOE issued a second waste determination under Section 3116 on the Tank Farm Facility (TFF) at the Idaho Nuclear Technology and Engineering Center (INTEC) in November 2006 (DOE, 2006b).

Table 1 Performance Objectives of 10 CFR Part 61, Subpart C

Section	Title	Text
10 CFR 61.40[1]	General Requirement	Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in §§ 61.41 through 61.44.
10 CFR 61.41[2]	Protection of the General Population from Releases of Radioactivity	Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.
10 CFR 61.42	Protection of Individuals from Inadvertent Intrusion	Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.
10 CFR 61.43	Protection of Individuals during Operations	Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by § 61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable.
10 CFR 61.44	Stability of the Disposal Site after Closure	The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.

1 In general, to assess compliance with the requirements of 10 CFR 61.40, the NRC will rely on its assessment of DOE's compliance with 10 CFR 61.41 through 10 CFR 61.44. Specifically, the NRC will view DOE as being in compliance with 10 CFR 61.40 as long as DOE is deemed to be in compliance with the other performance objectives.

2 As stated in the Staff Requirements Memorandum for SECY-05-0073, "Implementation of New USNRC Responsibilities under the National Defense Authorization Act of 2005 in Reviewing Waste Determinations for the USDOE," dated June 30, 2005 (NRC, 2005a), the dose standard is 25 millirem (mrem) total effective dose equivalent using the methodology of International Commission on Radiological Protection (ICRP)-26, "Recommendations of the International Commission on Radiological Protection" (ICRP, 1977).

The NRC staff prepared a TER (NRC, 2005b, 2006) and monitoring plan (NRC, 2007a, 2007b) for each facility. Section 1.1 of this report summarizes the NRC staff's approach to developing monitoring plans for DOE facilities in covered States. Additionally, DOE, on its own initiative, occasionally consults with the NRC staff on its non-HLW determinations at the Hanford site in the State of Washington and the West Valley Demonstration Project in the State of New York. However, neither Washington nor New York are covered States under the NDAA. Therefore, the NRC does not have a monitoring role at these sites under Section 3116 of the NDAA, and this report does not address these sites.

1.1 Summary of the NRC's National Defense Authorization Act Monitoring Approach

Section 10 of NUREG-1854 (NRC, 2007c) describes in detail the NRC's approach to compliance monitoring in accordance with Section 3116 of the NDAA. This section summarizes some of the information in Section 10 of NUREG-1854 to provide context for the NRC staff's observations in calendar year (CY) 2007.

Section 3116(b)(1) of the NDAA requires that the NRC shall "in coordination with the covered State, monitor disposal actions taken by the Department of Energy...for the purpose of assessing compliance with the performance objectives set out in subpart C of Part 61 of title 10, Code of Federal Regulations." Therefore, as described below, the NRC staff develops its monitoring plans in coordination with the covered States of Idaho and South Carolina.

The NRC has adopted a risk-informed and performance-based approach to monitoring DOE disposal activities under Section 3116 of the NDAA. A cornerstone of the NRC's approach is the identification of *key monitoring areas* (KMAs) related to DOE disposal actions that should be the focus of its monitoring efforts. The NRC staff identifies one or more *monitoring activities* to support each KMA in facility-specific monitoring plans. The performance objectives, KMAs, and monitoring activities form a hierarchy of plan elements that serves as the structure of each monitoring program.

Figure 1 illustrates the hierarchy of elements in an NRC monitoring plan. The following discussion summarizes the NRC staff's process for developing these elements.

Monitoring Areas

As the first step in the preparation of a monitoring plan for a specific waste determination, the NRC staff identifies monitoring areas. Monitoring areas are either programmatic or technical subject matter areas within which the staff will focus its monitoring efforts and which are important to DOE's ability to demonstrate compliance with the performance objectives of 10 CFR Part 61, Subpart C (see Table 1). The NRC staff typically identifies the monitoring areas during its review of the DOE draft waste determination and documents them in the TERs.

The NRC staff usually derives assurance that the requirements of 10 CFR 61.41, 10 CFR 61.42, and 10 CFR 61.44 will be met on the basis of DOE predictions of long-term disposal site performance. As described further below, DOE uses a *performance assessment* (PA) to predict disposal site performance, which most often involves calculations performed with the aid of computer-based models.

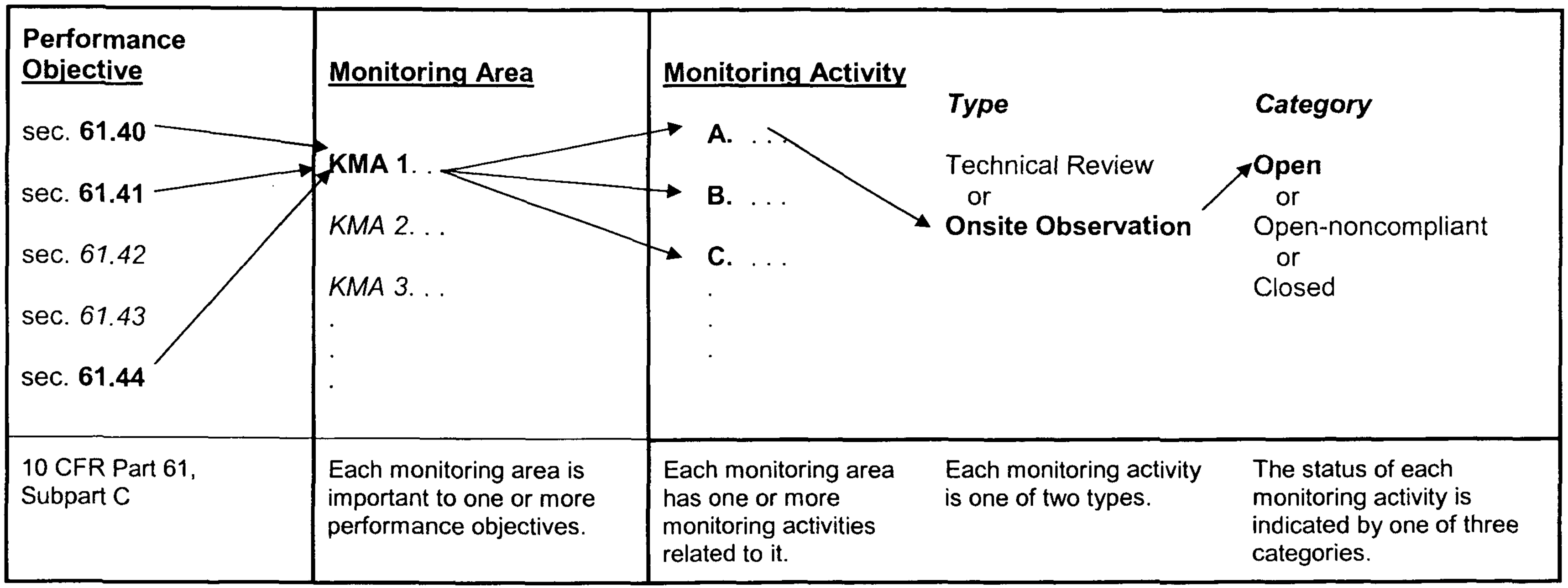

Figure 1 A hypothetical example of the relationship among 10 CFR Part 61 performance objectives, a single monitoring area, and the different types and categories of monitoring activities

This involves making certain assumptions about physical and chemical parameter values that DOE believes are appropriate for the disposal action. As such, monitoring areas that build confidence in the DOE selection of parameters and models are typically designated as KMAs.

A PA is an important tool used by both DOE and the NRC to identify which facility attributes are important to meeting the 10 CFR Part 61, Subpart C, performance objectives. In fact, DOE typically uses a PA to demonstrate compliance with the requirements in 10 CFR 61.41, 10 CFR 61.42, and 10 CFR 61.44, in recognition that long-term modeling predictions are needed to demonstrate compliance with performance objectives. A PA is a type of systematic (risk) analysis that addresses (1) what can happen, (2) how likely it is to happen, (3) what the resulting impacts are, and (4) how these impacts compare to specifically defined standards. The NRC staff believes that sufficient PA model support, coupled with observation of disposal actions carried out in conformance with detailed closure plans, is necessary for the staff to assess whether these performance objectives can be met in the future. Therefore, the designation of KMAs under 10 CFR 61.41, 10 CFR 61.42, and 10 CFR 61.44 is generally related to the assumptions and parameter values chosen by DOE in its PA.

The NRC staff identified additional monitoring areas for compliance with 10 CFR 61.43. These additional monitoring areas are not typically derived from the NRC staff's review of a DOE PA, as are KMAs. For example, the requirements of 10 CFR 61.43 apply to facility *operations*, including DOE site programs for ongoing personnel site access control, *worker* and public radiation protection, and environmental monitoring (EM) and surveillance. These DOE site programs are required to ensure compliance with the 10 CFR 61.43 performance objective, but are not evaluated as part of the long-term PA of the disposal facility.

As noted in Table 1, there are generally no specific monitoring areas tied to the requirements of 10 CFR 61.40. The NRC staff will rely on its assessment of DOE compliance with 10 CFR 61.41 through 10 CFR 61.44. Specifically, the NRC will view DOE as being in compliance with 10 CFR 61.40 as long as DOE is deemed to be in compliance with the other performance objectives.

Monitoring Activities

The next step in the preparation of a monitoring plan is the designation of one or more monitoring activities associated with each monitoring area. A monitoring activity is a specific type of NRC or covered State task or action with the purpose of monitoring DOE disposal actions to assess compliance with the performance objectives listed in 10 CFR Part 61, Subpart C. Examples of monitoring activities include NRC and covered State staff reviews of the results of DOE measurements of residual radioactivity in tanks before tank closure, NRC and covered State staff observations of periodic maintenance of disposal facility closure caps, and NRC and covered State staff observations of onsite radiation safety procedures during waste-handling operations. These examples show that some monitoring activities are near-term, short-duration activities that the NRC or covered States will close soon after the completion of the DOE disposal action. Other monitoring activities are long term, and the NRC or the affected covered State staff may conduct them in perpetuity.

In a few instances, the staff identified monitoring activities during preparation of the monitoring plan that the corresponding TER did not previously identify. As a result, these activities are not related to any particular monitoring area, but are tied directly to a 10 CFR Part 61, Subpart C, performance objective. The first two monitoring activities listed in Table B-1 in Appendix B to this report are examples of such activities.

For NRC staff's planning purposes, monitoring activities are also categorized by type as either technical reviews or onsite observations. Technical reviews may take the form of reviews of data, such as from EM and surveillance programs, or reviews of technical literature that supports important assumptions or parameter values in DOE PAs. Data reviews are a subset of, and supplement to, technical reviews which focus on real-time monitoring data that may also indicate future system performance (e.g., sampling and analysis of perched water underneath grouted vaults for changes in chemical conditions) or review of records or reports that can be used to directly assess compliance with performance objectives (e.g., review of radiation records). Onsite observations are coordinated with the affected covered State and the DOE site to ensure that the NRC staff has an opportunity to observe specific DOE disposal actions. The NRC staff conducts onsite observations in accordance with observation plans that are prepared in advance of the visits. The staff summarizes its conclusions in an observation report typically issued within 2 months of the onsite observation, unless DOE provides additional information following the site visit. In those cases, the reports are typically finished within 60 days of the staff completing its review of the additional information.

Based on their status, the NRC staff tracks monitoring activities (and associated KMAs) as either an *open activity*, an *open-noncompliant activity*, or a *closed activity.* The NRC characterizes a monitoring activity as an open activity when it has not obtained sufficient information to fully assess compliance with one or more 10 CFR Part 61, Subpart C, performance objectives. Should an ongoing open activity provide evidence that the performance objectives of 10 CFR Part 61, Subpart C, are currently not being met, or will not be met in the future, or if key aspects of the waste determination relied on to demonstrate compliance with the performance objectives are no longer supported, then the monitoring activity is categorized as an open-noncompliant activity. The NRC staff's TER and initial monitoring plan may also identify an open-noncompliant activity when the staff finds that the draft waste determination provides insufficient technical bases to determine that the performance objectives will be met. Finally, the NRC staff may categorize an ongoing monitoring activity as closed when it has either obtained sufficient information or received technical bases to fully assess compliance with one or more 10 CFR Part 61, Subpart C, performance objectives. However, the NRC staff may on its own initiative, upon evaluation of new information, reopen a closed activity or open a new monitoring activity relating to any monitoring area. Any DOE revisions to its PAs may also trigger a review and possible revision of the NRC's monitoring plans.

Coordination with Covered States

The NRC staff consulted with the States of South Carolina and Idaho during the preparation of the monitoring plans for Saltstone and the Idaho National Laboratory (INL) INTEC TFF. For Saltstone, the staff had early interactions with the South Carolina Department of Health and Environmental Control during its review of the waste determination and later sought comments on the draft monitoring plan. As a result of these interactions, the staff considered in the development of its plan the regulatory activities of South Carolina relating to both a State wastewater permit for the Saltstone Production Facility (SPF) and a State industrial solid waste permit for the Saltstone Disposal Facility (SDF). The staff plans to leverage South Carolina's activities pertaining to these permits and avoid duplication of effort.

In CY 2009, the NRC staff coordinated each onsite monitoring activity with the State of South Carolina and in each activity at least one state representative was present onsite at the time of the activity.

Similarly, for the INL INTEC TFF, the staff engaged the Idaho Department of Environmental Quality (DEQ) early in the consultation process during the staff's review of the DOE waste determination. The two primary State regulatory responsibilities related to the TFF are (1) Resource Conservation and Recovery Act closure under the Hazardous Waste Management Act and (2) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulatory activities associated with historical releases from the ancillary equipment associated with the TFF that resulted in soil and ground water contamination. In its monitoring plan, the NRC considered these and other nonregulatory environmental surveillance activities and plans to leverage Idaho's activities to avoid duplication of effort.

Status of Monitoring Activities

Tables B-1 and B-2 in Appendix B to this report summarize the monitoring areas and the current types and categorization of monitoring activities for SRS salt waste disposal and the INL INTEC TFF; Sections 2 and 3, respectively, in the body of this report discuss them in detail. Monitoring plans developed in consultation with the covered States (NRC, 2007a and 2007b) provided the information presented in Appendix B.

Open Issues — As the NRC staff completes technical reviews and onsite observations, it may identify *open issues* that arise during monitoring activities that require additional follow-up by the staff or additional information from DOE to address questions the NRC staff has raised regarding DOE disposal actions.

Recommendations — The NRC staff also provides *recommendations* to DOE, the purpose of which is to provide DOE with the NRC staff's insights on one or more aspects of the disposal action that NRC is monitoring. Recommendations may address the following:

i. ways that DOE can make progress on closing any open activities in the staff's monitoring plan;
ii. a monitoring area for which an open issue has been previously identified and closed and for which the NRC staff recommends further action to strengthen some aspect of the DOE disposal action;
iii. and monitoring areas for which no open issues or concerns were previously raised, but for which the NRC staff recommends further improvements to DOE disposal actions.

This report assigns a unique alphanumeric monitoring activity code for NRC staff tracking purposes to each monitoring activity described in the staff's monitoring plans for the SRS Saltstone Facility and the INL INTEC TFF. Tables B-1 and B-2 in Appendix B to this report list the monitoring activities and monitoring activity codes. The monitoring activity code contains information about the DOE site; facility; the primary applicable 10 CFR Part 61, Subpart C, performance objective; the monitoring area; and the type of monitoring which is performed (e.g., onsite observation (O) or technical review (T)). The key for the monitoring activity codes is as follows:

Site	Facility	Performance Objective	Key Monitoring Area or Factor	Activity Number	Type of Activity
SRS- or INL-	SLT- or TFF-	41- 42- 43- 44-	01- 02- 03- RE[3] etc.	01- 02- 03- etc.	T or O

For example, the third monitoring activity listed in the NRC monitoring plan for the SRS Saltstone Facility (and, thus, the entry pertaining to the third Factor in Table B-1 of this report) is coded "SRS-SLT-41-01-03-T." For tracking purposes, at least one monitoring activity code is cited for each open issue and recommendation described in this report.

Section 10 of the staff's guidance in NUREG-1854 (NRC, 2007c) contains a complete description of the NRC staff's procedures for reporting instances of *noncompliance* under Section 3116(b)(2) of the NDAA.

1.2 Contents of this Report

This report summarizes monitoring activities conducted by the NRC staff in CY 2009 in accordance with two active monitoring plans (NRC, 2007a and 2007b). As described in the monitoring plans and Section 10 of NUREG-1854 (NRC, 2007c), the NRC will provide this periodic compliance monitoring report to DOE and the State for information purposes. In addition, the report will be made publicly available on the NRC's Web site.

Separate sections of this report address the NRC staff's monitoring activities corresponding to each NRC-published monitoring plan. For each NRC-published monitoring plan, this report covers the following topics:

- NRC staff technical reviews, including the following:
  - monitoring activities conducted this year
  - whether the NRC staff continues to have reasonable assurance that performance objectives are met and will be met in the future
  - the basis for the NRC staff's conclusions (e.g., independent analysis, supporting studies, expert opinion)
  - NRC staff recommendations

[3] RE stands for radiation protection or an environmental protection monitoring area not separately identified as a either a key monitoring area or factor in the NRC's review of the DOE PA.

- open issues that the NRC staff identified during this year's monitoring activities

- NRC staff observation visits to sites in covered States
- whether DOE has revised or plans to revise PAs
- whether NRC staff monitoring activities are closed, open, or open-noncompliant
- monitoring activities that were previously closed but reopened this year
- new monitoring activities identified during the year
- actions or results that might change the status of any open-noncompliant activities
- activities that were closed and conditions for reopening closed activities
- new developing issues and disposition of prior years' developing issues
- significant changes to the disposal design

This report focuses on the open issues identified by the NRC staff and its recommendations to DOE pertaining to NRC monitoring activities in CY 2009. Appendix C to this report contains the staff's observation reports, which more completely describe the site visits, including the staff's activities for which no open issues were raised, no recommendations were provided, and no findings of noncompliance were made. There were no previous reports on the staff's technical reviews in CY 2009. Therefore, this report presents a complete discussion of the staff's technical reviews.

2. MONITORING AT THE SAVANNAH RIVER SITE SALTSTONE FACILITY IN 2009

In May 2007, the NRC staff issued its monitoring plan for salt waste disposal at the SRS (NRC, 2007b), for which DOE had previously issued its final waste determination (DOE, 2006a). Table 2 lists the current NRC monitoring plans. In the salt waste disposal monitoring plan, the NRC staff identified eight KMAs, or *factors;* an additional monitoring area for EM and radiation protection during facility operations; and a total of 39 monitoring activities. Table B-1 in Appendix B to this report describes all monitoring areas and related monitoring activities for salt waste disposal.

Table 2 Current NRC Monitoring Plans under the National Defense Authorization Act

Facility	Monitoring Plan Title	Date	ADAMS Accession No.
SRS Salt Waste Disposal	"U.S. Nuclear Regulatory Commission Plan for Monitoring the U.S. Department of Energy Salt Waste Disposal at the Savannah River Site in Accordance with the National Defense Authorization Act for Fiscal Year 2005" (NRC, 2007b)	May 3, 2007	ML070730363
INL INTEC Tank Farm Facility	"U.S. Nuclear Regulatory Commission Plan for Monitoring Disposal Actions Taken by the U.S. Department of Energy at the Idaho National Laboratory Idaho Nuclear Technology and Engineering Center Tank Farm Facility in Accordance with the National Defense Authorization Act for Fiscal Year 2005" (NRC, 2007a)	April 13, 2007	ML070650222

2.1 Technical Reviews

In 2009, the NRC staff conducted six technical reviews related to the Saltstone Facility. The reviews are of reports provided to NRC staff by DOE. The staff reviewed these reports in accordance with the NRC monitoring plans referenced above. A list of the NRC staff's technical review summaries for each report reviewed is provided below. Appendix D to this report provides the complete NRC staff summaries.

Table 2: NRC Technical Reviews Completed in Calendar Year 2009

NRC Technical Review Report	DOE Reports Reviewed [ADAMS Acc. No.]	Review ADAMS Acc No.	Review Completion Date
"Soil Contamination Data and Associated Analysis for Vault 4 of the Saltstone Disposal Facility"	Kubilius, W., Z-area Vault 4 Phase 2 Soil Sample Analytical Data Report, ERD-EN-2008-0083, Savannah River Site, December 2008. [ML090120404] Rosenberger, K. H., Comparison of Vault 4 Soil Sampling Results to Existing Unreviewed Disposal Question Evaluation SRS-REG-2007-00041, SRNS-J2100-2008-00013, SRNS. December 3, 2008 [ML090120429] Rosenberger, K. H., Unreviewed Disposal Question Evaluation: Evaluation of Liquid Weeping from Saltstone Vault 4 Exterior Walls, SRS-REG-2007-00041, Revision 1, Westinghouse Savannah River Company, Aiken, South Carolina, April 2008. [ML090120475] Kent, E., Letter to J. Buczek, WSRC, re: Samples received on February 14, 2008, GEL Laboratories, March 13, 2008. [ML090120539] Kent, E., Letter to J. Buczek, WSRC, re: Samples received on July 16, 2008, GEL Laboratories, September 16, 2008. [ML090120546]	ML092300572	09/01/2009

NRC Technical Review Report	DOE Reports Reviewed [ADAMS Acc. No.]	Review ADAMS Acc No.	Review Completion Date
"Evaluation of Sulfate Attack on Saltstone Vault Concrete and Saltstone, Part I: Final Report," "Evaluation of Sulfate Attack on Saltstone Vault Concrete and Saltstone, Part II: Test Methods to Support Moisture and Ionic Transport Modeling Using the Stadium® Code"	Langton, C., Evaluation of Sulfate Attack on Saltstone Vault Concrete and Saltstone, Part I: Final Report, SRNS-STI-2008-00050, Rev 0, SRNL, SRNS. August 19, 2008 [ML090150306] Langton, C., Evaluation of Sulfate Attack on Saltstone Vault Concrete and Saltstone, Part II: Test Methods to Support Moisture and Ionic Transport Modeling using the STADIUM® Code, SRNS-STI-2008-00052, Rev 0, SRNL, SRNS. August 19, 2008 [ML090150312]	ML092300610	09/01/2009
"Hydraulic and Physical Properties of Saltstone Grouts and Vault Concretes"	Dixon, K., J. Harbour, and M. Phifer, Hydraulic and Physical Properties of Saltstone Grouts and Vault Concretes, SRNL-STI-2008-00421, Revision 0, SRNL, WSRC. November 2008 [ML090150298]	ML092300670	08/25/2009
"Saltstone and Concrete Interactions with Radionuclides: Sorption (Kd), Desorption, and Reduction Capacity Measurements"	Kaplan, D. I., K. Roberts, J. Coates, M. Siegfried, S. Serkiz, Saltstone and Concrete Interactions with Radionuclides: Sorption (K_d), Desorption, and Reduction Capacity Measurements, SRNS-STI-2008-00045, SRNL, WSRC. October 2008 [ML090150234]	ML092890633	10/23/2009
"Thermodynamic and Mass Balance Analysis of Expansive Phase Precipitation in Saltstone"	Denham, Miles, Thermodynamic and Mass Balance Analysis of Expansive Phase Precipitation in Saltstone, WSRC-STI-2008-00236, SRNL, WSRC. May 2008 [ML083400055]	ML093030220	08/26/2009
"Saltstone Vault #2 Interior Lining Review"	Skidmore, T. E. and K. D. Billings, Saltstone Vault #2 Interior Lining Review (U), WSRC-TR-2008-00090, Rev. 0, SRNL, WSRC. May 2008. [ML083400060]	ML093100197	11/12/2009

2.2 Onsite Observations

In 2009, the NRC staff conducted three observation visits: March 25–26, June 3, and August 10–14.

The staff's March 25–26, 2009, onsite observation visit focused primarily on the performance objectives found in 10 CFR 61.41 and 10 CFR 61.43. Specifically, the staff observed DOE's ongoing construction of disposal cells at the SDF and discussed with DOE and DOE contractor staff the methods used to estimate the inventory of radionuclides in the SDF. The staff also discussed with DOE and DOE contractor staff 10 of 14 technical reports provided to the NRC staff since November 2008 (see also Section 2.1 of this report). Appendix C to this report contains the observation report, dated May 22, 2009, for this visit (NRC, 2009a). Since saltstone production operations could impact the long-term stability of the SDF after its closure, this observation also partially assessed the performance objective in 10 CFR 61.44.

The staff's June 3, 2009, onsite observation visit focused primarily on the performance objective found in 10 CFR 61.41. Specifically, the staff observed DOE's ongoing construction of disposal cells at the SDF. Appendix C to this report contains the observation report, dated September 30, 2009, for this visit (NRC, 2009c). Again, since saltstone production operations could impact the long-term stability of the SDF after its closure, this observation also partially assessed the performance objective in 10 CFR 61.44.

The staff's August 10 - 14, 2009, onsite observation visit focused on assessing compliance with all four of the performance objectives in 10 CFR Part 61 by observing DOE's review process of the performance assessment for the SDF. Specifically, the staff observed the onsite portion of the Low-Level Waste Disposal Facility Federal Review Group (LFRG). Appendix C contains the observation report, dated October 1, 2009, for this visit (NRC, 2009d).

2.2.1 March 2009 Onsite Observation

Monitoring Areas

As discussed more fully in the observation report (Appendix C), the NRC staff observed ongoing construction activities. The staff also evaluated DOE and DOE contractor staff assumptions and data used to quantify the inventory of radionuclides in liquid waste that is transferred to the SDF.

Disposal Cell Construction - The NRC staff monitors ongoing construction of disposal cells, as described in Section 3.2.3, "Vault Construction," of the staff's monitoring plan (NRC, 2007b). The general purpose of NRC staff observations of ongoing construction of SDF Cells 2A and 2B is to identify noticeable deviations from the vault design, focusing on changes that could affect potential pathways for water to intrude into the vaults, such as penetrations or joints.

Radionuclide Inventory Estimates - The NRC staff monitors feed tank sampling and waste sampling, as described in Section 3.1.1, "Data Reviews"; Section 3.1.6, "Factor 6—Feed Tank Sampling"; Section 3.2.2, "Waste Sampling"; and Section 3.1.8, "Factor 8—Removal Efficiencies," of the staff's monitoring plan (NRC, 2007b).

Technical Reviews - NRC staff continues to monitor the quality of saltstone grout and vault concrete, as described in Section 3.1.2, "Factor 1—Oxidation of Saltstone"; Section 3.1.3, "Factor 2—Hydraulic Isolation of Saltstone"; and Section 3.1.4, "Factor 3—Model Support," of the staff's monitoring plan (NRC, 2007b).

Results

Disposal Cell Construction - At the time of the staff's visit, the base mud mat, geosynthetic clay liner, 100-mil high-density polyethylene liner, Type V mud mat, and floor had been installed for Cells 2A and 2B, and the Type V concrete floor was curing under plastic covers. Rebar pedestals had been cast in place in the floor for the 48 columns that will support the roof in each cell. Forms were constructed at various locations on the ground outside the cells for casting 32 15-ton wall panels for each cell, but no wall panels had been cast at the time of the observation. The staff identified no open issues during the observation of disposal cell construction.

Radionuclide Inventory Estimates - DOE contractor staff explained the data and assumptions that are used to prepare quarterly Saltstone permit reports. These reports and information from a Tank 50 material balance worksheet, along with other supporting information, is used to estimate volume-weighted concentrations of radionuclides that are sent to the SDF each quarter. DOE contractor staff also explained the discrepancy between the results of these quarterly reports and the quarterly totals of radionuclides in liquid waste. The NRC and DOE contractor staff also discussed how semiannual Tank 50 confirmatory samples taken for measurements of radionuclide concentrations are used to adjust estimates of radionuclide inventory in Tank 50, which are more routinely updated using process knowledge and sampling results for influent liquid wastes to Tank 50. Staff observations resulted in no new open issues or recommendations at this time.

Technical Reviews - The NRC staff discussed with DOE and DOE contractor staff 10 of 14 technical reports provided to NRC staff since November 2008. These reports covered the results of studies on soil contamination in the vicinity of Vault 4 and the results of physical and chemical studies on both actual disposal cells and laboratory-prepared saltstone grout and vault concrete. The NRC staff identified one new open issue (Open Issue 2009-1), in which the staff determined that DOE should provide additional support for its assumptions that (1) technetium-99 in salt waste is converted to its reduced chemical form in saltstone grout during the curing of saltstone grout, and is thereby strongly retained in saltstone grout, and (2) the sorption of dissolved technetium-99 onto saltstone grout and vault concrete is consistent with K_d values for technetium-99 assumed in the performance assessment.

2.2.2 June 2009 Onsite Observation

Monitoring Areas

As discussed more fully in the observation report (Appendix C), the NRC staff observed ongoing construction at SDF Cells 2A and 2B and interviewed key DOE and DOE contractor personnel. At the time of the staff's visit, all vertical wall panels were installed for both cells.

The observation of DOE vault construction relates to Factor 1, "Oxidation of Saltstone"; Factor 2, "Hydraulic Isolation of Saltstone"; and Factor 3, "Model Support," which were identified in the NRC monitoring plan for the SRS SDF (NRC, 2007b). The general purpose of NRC staff observations of ongoing construction of the Saltstone Facility disposal cells 2A and 2B is to identify noticeable deviations from the vault design, focusing on changes that could affect potential pathways for water to intrude into the vaults, such as penetrations or joints. In addition to material effects, The NRC staff paid particular attention to those processes contributing to the assembly and installation of the vault wall panels.

Results

The NRC staff observed ongoing construction at Saltstone Facility disposal cells 2A and 2B. At the time of the staff's visit, the cell floors and all wall panels had been fully installed for disposal cells 2A and 2B, and most of the wall panel joints had been poured for disposal cell 2B. The NRC staff also observed construction activities associated with concrete placement in some of the 32 closure strips of disposal cell 2B.

The staff identified no open issues during the observation of disposal cell construction. However, the staff observed deviations of required concrete codes and standards. The NRC staff will discuss these deviations with DOE personnel in future meetings. The staff made one recommendation related to the deviations from required concrete codes and standards.

2.2.3 August 2009 Onsite Observation

Monitoring Areas

As discussed more fully in the observation report (Appendix C), the NRC staff attended the LFRG Review Team site visit for the review of the report entitled, "Performance Assessment (PA) for the Saltstone Disposal Facility at the Savannah River Site (LWP-RIP-2009-00011)." The NRC staff is reviewing the update to the SDF, as described in Section 3.1.9, "Performance Assessment Process Review," of the NRC staff's monitoring plan (NRC, 2007b).

The observation of the LFRG PA review relates to the technical review factors identified in the NRC monitoring plan for the SRS SDF (NRC, 2007b). The monitoring plan states the importance of the NRC staff's evaluation of revisions and updates made to the PA to determine whether the PA continues to provide reasonable assurance that the long-term performance of the wasteform and its surrounding system will maintain public health and safety. The general purpose of the NRC staff's review of the SDF PA revision is continued verification of compliance with the performance objectives listed in 10 CFR Part 61, Subpart C.

The LFRG consists of Federal employees from DOE Headquarters and DOE field organizations and typically includes technical experts subcontracted from other DOE sites. The group performs a review of PAs and composite analyses of all DOE low-level waste (LLW) disposal facilities and supports the process of granting disposal authorization statements. The DOE Office of Environmental Management tasks the LFRG with providing the information necessary to determine whether the design, construction, operation, maintenance, and closure of DOE's LLW disposal facilities sufficiently protect public health and safety.

Results

The NRC staff observed that the LFRG review team evaluated the PA and supporting documentation to confirm that the PA is complete, thorough, and technically supported, and the conclusions are valid and acceptable. The staff identified no open issues during the observation of the LFRG review.

2.3 Summary of Open Issues and Recommendations

Tables 3 and 4 (see Section 4) summarize those recommendations and open issues from the NRC staff's monitoring activities of DOE salt waste disposal activities in CY 2009 that the staff will continue to monitor in CY 2010.

Based on its observations, the NRC staff continues to conclude that reasonable assurance exists that the applicable criteria of the NDAA can be met if key assumptions made in the DOE waste determination analyses prove to be correct. In accordance with the requirements of the NDAA and consistent with its monitoring plan for the Saltstone Disposal Facility, the NRC will continue to monitor DOE disposal actions at the SRS. The monitoring activities are expected to be an iterative process, and several onsite observation visits and technical reviews of various reports, studies, and other documents may be necessary to obtain the information needed to close all of the current open issues, as well as issues that may be opened in the future.

3. MONITORING AT THE IDAHO NATIONAL LABORATORY IDAHO NUCLEAR TECHNICAL AND ENGINEERING CENTER IN 2009

The NRC issued its monitoring plan for INTEC on April 13, 2007 (see Table 2 above). The NRC staff identified five key monitoring areas, one monitoring area on radiation protection and EM areas under 10 CFR 61.43, and a total of 31 monitoring activities in this plan. Table B-2 in Appendix B to this report summarizes the monitoring areas and related monitoring activities.

3.1 Technical Reviews

Technical Review Area for KMA 3

> Relevant recent and future monitoring data and modeling activities should continue to be evaluated to ensure that hydrological uncertainties that may significantly alter the conclusions in the PA and TER are addressed. If significant new information is found, this information should be evaluated against the PA and TER conclusions (NRC, 2006 and 2007a).

The NRC staff developed KMA 3 as a result of its analysis in the TER for the INTEC TFF draft waste determination (NRC, 2006), which showed a number of uncertainties associated with the DOE ground water model used to support the demonstration of compliance with the performance objective found in 10 CFR 61.41 for protection of the general population from releases of radioactivity. Uncertainties included (1) hydrogeologic conceptual model uncertainty broadly affecting flow and transport of radiological constituents in the subsurface, (2) infiltration rates that affect travel times and flux of contaminants to the Snake River Plain Aquifer (SRPA), and (3) Big Lost River seepage impacts that influence travel paths and lengths and dilution of radiological constituents during unsaturated zone transport. However, assuming the engineered barrier system performs as well as is assumed in DOE's performance assessment, the NRC staff concluded in the TER that natural system uncertainty could be managed with conservative assumptions. For example, minimal credit for dilution from SRPA flow alone for the key radionuclides technetium-99 and iodine-129 and minimal credit for dilution, sorption, and decay for key radionuclide strontium-90 is sufficient for DOE to demonstrate compliance with 10 CFR 61.41. The NRC staff's monitoring plan for the INL INTEC TFF (NRC, 2007a) provides additional details on how hydrogeologic uncertainties affect the potential risk from highly radioactive radionuclides identified for the INTEC TFF.

As stated in its monitoring plan (NRC, 2007a), the NRC staff will continue to stay abreast of relevant monitoring and modeling activities conducted by DOE, other agencies, or independent researchers until such time that it concludes that risk-significant hydrologic uncertainties are adequately addressed and overall system performance is adequately constrained. However, because only minimum credit for natural system performance is needed if the engineered system performs as well as assumed in the DOE PA, the status of this KMA will remain open until KMA 2 related to performance of the engineered barrier system is closed. If issues arise during evaluation of KMA 2, then KMA 3 will become more important. The NRC expects to close KMAs 2 and 3 in tandem.

As part of KMA 3 monitoring activities, the NRC staff typically reviews ground water monitoring reports for perched and saturated ground water at INTEC conducted under the CERCLA program. Data from historical releases collected under the CERCLA program are helpful to the NRC staff with respect to evaluating hydrogeological system uncertainties at INTEC TFF. It is important to note that the CERCLA program addresses risks associated with historical releases, which are are not considered when evaluating potential compliance with performance objectives under the NDAA (i.e., only future releases are considered when evaluating compliance with the performance objectives of 10 CFR Part 61). Thus, CERCLA information is reviewed for the sole purpose of providing risk insights on future natural system performance rather than as a measure of contemporaneous compliance with performance objectives for LLW disposal under the NDAA.

Results from ground water sampling scheduled for spring 2009 were not reported in a timely enough manner to allow inclusion in this year's periodic compliance monitoring report. Ground water sampling data for the INTEC TFF are expected to be available in the summer of 2010; next year's periodic compliance monitoring report will include the NRC review results for the spring 2009 monitoring. However, the NRC staff was able to review other pertinent hydrogeological study information as discussed below.

As provided in the Tank Farm Soil and INTEC Groundwater Remedial Design/Remedial Action Work Plan and associated Long-Term Monitoring Plan (DOE, 2008 and 2009a), DOE Idaho prepared an annual report (DOE, 2009b) describing maintenance, inspection, and other activities performed to address contaminated soils and ground water at INTEC, as specified in the Record of Decision for the Tank Farm Soil and INTEC Groundwater Operable Unit 3-14, signed in May 2007 (DOE, 2007). DOE's annual report for INTEC soils and ground water (DOE, 2009b) is not intended to interpret data, form conclusions, or determine the effectiveness of the selected remedy. These topics are the subject of a 5-year review document DOE is planning to prepare in 2010. The NRC staff expects to be able to review the 5-year review document in time to present the results of its review in the next periodic compliance monitoring report.

Current risks associated with tank farm soil and INTEC ground water from previous releases include external exposure to soil contaminated with cesium-137 and ingestion of contaminated SRPA ground water. The SRPA currently contains significant concentrations of strontium-90 and nitrate from previous injection well operations and technetium-99 resulting from tank farm releases (DOE, 2009c). If left unmitigated, perched water could become a continuing source of ground water contamination to the SRPA above certain CERCLA action levels (e.g., maximum contaminant levels) beyond 2095. CERCLA modeling shows that, with decreased infiltration in a 9.5-acre area surrounding the TFF, the SRPA could meet action levels by 2095. This 9.5-acre area is designated a recharge control zone under the selected remedy. Thus, remedial activities are focused on the control of recharge to the subsurface.

Activities reported in the annual report include inspections, monitoring, radiological surveys, and maintenance of various water management and infiltration control measures implemented at INTEC (e.g., storm water collection ditches, evaporation pond, culverts, and infiltration barriers). Evaluation of perched water levels indicates that unknown sources of water from operations may continue to recharge the subsurface at INTEC. Potential sources will continue to be investigated. While trend data show the potential for above-average snowfall accumulation and subsequent melting and infiltration to increase perched water levels at INTEC in the short term (e.g., higher than average snowfall and infiltration in the winter of 2007–2008), a longer term general decline in shallow perched water volumes over the period from 2006 through 2008 has been observed.

The NRC staff identified no new and significant information that would invalidate NRC staff's TER conclusions. The staff will continue to assess the mobility of radiological constituents through review of INTEC monitoring data expected to available later in the year. Big Lost River seepage near the INTEC TFF will also continue to be evaluated to determine its impact on ground water flow and transport mechanisms near the TFF. The NRC staff will continue to review information and data generated under the CERCLA monitoring program to support KMA 3. The NRC staff continues to have reasonable assurance that performance objectives will be met for residual waste disposal at the INTEC TFF.

Technical Review Area for Key Monitoring Area 4

> Closure and post-closure operations (until the end of active institutional controls, 100 years) will be monitored to ensure that the 10 CFR 61.43 performance objective (protection of individuals during operations) can be met. As part of this assessment radiation records, environmental monitoring, and exposure assessment calculations may be reviewed (NRC, 2007a).

KMA 4 in the NRC's TER for INTEC TFF addresses DOE compliance with the performance objective found in 10 CFR 61.43 related to protection of individuals during operations. To evaluate this performance objective, the INL monitoring plan provides that the NRC staff will review DOE worker radiation records, DOE's program to maintain worker doses as low as is reasonably achievable (ALARA), and offsite dose assessment methods and results.

Significant closure activities (e.g., pipe grouting) occurred at INTEC TFF in 2008. The NRC staff evaluated DOE's worker radiation protection program during an onsite observation visit reported in last year's periodic compliance monitoring report (NRC, 2009b). No significant closure activities occurred at the INTEC TFF in CY 2009. Thus, no onsite observations evaluating DOE's worker radiation protection program occurred during this compliance monitoring period. Technical review activities associated with protection of members of the public under KMA 4 discussed in this section included review of environmental surveillance data and analysis performed by Stoller Corporation and Idaho DEQ (DOE, 2009c).

Current activities at INTEC include storage of spent nuclear fuel in a modern water basin and in dry storage facilities, management of HLW calcine and sodium-bearing liquid waste, and the operation of the Idaho CERCLA Disposal Facility, which includes a landfill, evaporation ponds, and a storage and treatment facility.

Since specific monitoring data for the INTEC TFF are not readily available, the NRC staff reviewed DOE's environmental surveillance reports as well as the Idaho DEQ's INL Oversight Program's annual report for CY 2008 (Idaho DEQ, 2009). DOE's environmental monitoring program is used to evaluate the impacts of INL operations on members of the public, while the environmental surveillance program evaluates air, soil, water, vegetation, animals, and foodstuffs on and around the INL site to confirm compliance with applicable laws and regulations. Since these reports cover the entire site and are not focused specifically on the INTEC TFF, the NRC considers these to be a bounding analysis for the public.

The DOE Idaho environmental surveillance program, which performs monitoring activities on the INL site, at the INL site boundary, and off site, emphasizes the measurement of airborne radionuclides because the air transport pathway is considered to be the principal pathway from the INL site for potential releases to the public. Results show that all radionuclide concentrations in ambient air samples were below DOE standards and within historical measurements and are considered to have no measurable impact on the environment. Two different computer programs were used to estimate doses. The Clean Air Act Assessment Package 1988 (CAP-88) computer code was used to calculate the dose to the hypothetical, maximally exposed individual (MEI), and the mesoscale diffusion (MDIFF) air dispersion model was used to estimate the dose to the population within 50 miles (80 kilometers) of the INL site facilities. The maximum dose to the MEI was calculated to be 1.31 microsieverts per year (μSv/yr) (0.131 millirem per year (mrem/yr)), well below the applicable radiation protection standard of 100 μSv/yr (10 mrem/yr). For comparison, the dose from natural background radiation was estimated to be 3.54 millisievert (354 mrem). The maximum potential population dose to the approximately 300,656 people residing within a 50-mile (80-kilometer) radius of any INL site facility was calculated as 7.8×10^{-3} person-Sv (0.78 person-rem), which is below that expected from exposure to background radiation (i.e., 1,060 person-Sv or 106,432 person-rem).

Surface water and ground water pathways are not considered to be major contributors to public dose because no surface water flows off the INL site and no radionuclides from the INL site have been found in offsite drinking water wells.

The maximum potential individual doses from consumption of waterfowl and big game animals from the INL site were estimated from the highest concentrations of radionuclides measured in samples collected at the site. Current trends show that this dose is lower than the maximum dose estimates from previous periods. The maximum potential dose of 0.52 μSv (0.052 mrem) for waterfowl samples is substantially below the 8.9 μSv (0.89 mrem) estimated from the most contaminated ducks collected between 1993 and 1998 from sewage lagoons adjacent to the radioactive wastewater ponds. It is assumed that the ducks used the radioactive wastewater lagoons while in the area. Although considered in the past, contributions from the game animal consumption pathway to population dose were not considered in CY 2008 because only a limited percentage of the population hunts game, few of the animals killed have spent time on the INL site, and most of the animals that do migrate from the INL site have low concentrations of radionuclides in their tissues by the time they are harvested. In general, the dose contributions from the game animal consumption pathway can be expected to be less than the sum of the population doses from inhalation of air, submersion in air, ingestion of vegetables, and deposition on soil. Based on the graded approach used to evaluate nonhuman biota, it can also be concluded that there is no evidence that INL site-related radioactivity associated with the soil or water is harming the resident plant and animal populations.

The NRC staff also reviewed environmental data collected by the State of Idaho. The Idaho DEQ maintains an environmental surveillance program (e.g., air, water (surface and ground), soil, and milk sampling from on and off the INL site) to independently evaluate DOE's monitoring program and assess the environmental impacts from INL facilities. Idaho DEQ publishes quarterly and annual reports that provide monitoring data or analysis. The NRC staff has concluded that Idaho DEQ's independent environmental surveillance program is sufficient to address this technical review area. Therefore, the NRC staff plans to continuously review data, analysis, and conclusions provided in Idaho DEQ quarterly and annual reports to help reach its conclusions regarding compliance with the 10 CFR 61.43 performance objective.

Idaho DEQ posts the latest quarterly and annual reports on the Idaho DEQ's INL oversight Web site (see http://www.deq.idaho.gov/inl_oversight). The NRC staff reviewed the annual report as well as the quarterly reports for CY 2008 to determine potential offsite impacts to members of the public, unexplained or unexpected releases of radioactivity from operations at INTEC, and trends with respect to contaminant concentrations from onsite monitoring wells. While the monitoring network at INTEC is not as extensive as it is for the CERCLA program, onsite ground water monitoring data collected by Idaho DEQ also help to validate data collected by DOE and its contractors.

As indicated in the 2008 annual report (Idaho DEQ, 2009), data collected during the 2008 calendar year were generally consistent with historic trends. Concentrations of radioactivity in air, soil, and milk samples were consistent with background levels. Radiation levels were also consistent with historic background measurements. In general, there appears to be good agreement between the environmental monitoring data reported by Idaho DEQ and data collected by DOE and its contractors.

The NRC staff believes that the consistency of data collected by Idaho DEQ and DOE provides confidence that both programs can be used to evaluate the offsite environmental impacts associated with INL operations. Based, in part, on its review of environmental surveillance data collected by DOE and the State, the NRC staff continues to have reasonable assurance that the 10 CFR 61.43 performance objective related to protection of individuals during operations will be met.

The NRC staff will continue to evaluate worker and public exposure data or estimates through review of worker radiation records and review of environmental surveillance reports as the INTEC TFF closure activities progress in support of the technical review activities identified for KMA 4 in the INL monitoring plan (NRC, 2007a). The level of monitoring is expected to be higher during active closure operations conducted through the year 2012.

3.2 Onsite Observations

Because there were no ongoing non-HLW disposal activities at INTEC in 2009, the NRC staff conducted no onsite observation visits. The staff did however perform a number of technical reviews identified in the monitoring plan for INTEC.

3.3 Summary of Open Issues and Recommendations

The NRC staff's monitoring activities of the DOE INTEC TFF activities in CY 2009 resulted in no recommendations or open issues. During technical reviews performed in 2009, the NRC staff evaluated information that DOE continues to develop pertaining to hydrological uncertainties at the TFF and EM data produced by both the State of Idaho and DOE.

The NRC staff opened no new monitoring activities (see Table B-2 in Appendix B). The staff identified no open activities as open-noncompliant. Therefore, the NRC plans no revisions to the monitoring plan in response to monitoring activities in CY 2009.

The NRC staff continues to have reasonable assurance that the 10 CFR Part 61, Subpart C, performance objectives are being met and will be met in the future.

4. OPEN ISSUES AND RECOMMENDATIONS

Tables 3 and 4 summarize the open issues and recommendations, respectively, that the NRC staff identified during its ongoing monitoring of DOE waste disposal actions from January 1, 2007, through December 31, 2009.

Table 3 Summary Description of Open Issues in the NRC Section 3116(b) Monitoring Program

Open Issues		
Number	**Description**	**Status**
2007-1	At the SRS Saltstone Facility, as a result of variations in the composition of saltstone grout actually produced at the SRS SPF, DOE should determine the hydraulic and chemical properties of as-emplaced saltstone grout. Inadequate saltstone grout quality could result in disposal actions that are not compliant with the 10 CFR 61.41 performance objective.	Open
2007-2	At the SRS Saltstone Facility, DOE should demonstrate that intrabatch variability, flush water additions to freshly poured saltstone grout at the end of each production run, and additives used to ensure processability are not adversely affecting the hydraulic and chemical properties of the final saltstone grout. DOE should show that hydraulic and chemical properties are consistent with the assumptions in the waste determination or show that any deviations are not significant with respect to demonstrating compliance with the performance objectives.	Open
2007-3	At the SRS Saltstone Facility, DOE should reassess the risk significance of the as-built conditions of Vault 4 in light of the presence of contaminated seeps on the exterior wall of Vault 4.	Closed
2009-1	At the SRS Saltstone Facility, DOE should demonstrate that (1) technetium-99 in salt waste is converted to its reduced chemical form in saltstone grout during the curing of saltstone grout and is thereby strongly retained in saltstone grout, and (2) the sorption of dissolved technetium-99 onto saltstone grout and vault concrete is consistent with the K_d values for technetium-99 assumed in the performance assessment.	Open

Table 4 Summary Staff Recommendations under the NRC Section 3116(b) Monitoring Program

Recommendations	
Number	**Description**
2007-1	At the SRS Saltstone Facility, the NRC staff recommends independent verification of the material characteristics of blast furnace slag to provide additional assurance of the quality of saltstone grout.
2007-2	At the SRS Saltstone Facility, the NRC staff recommends that DOE either ensure that the accumulation of solids is monitored during processing or act to mitigate the potential for solids accumulation.
2007-3	At the INL INTEC TFF, the NRC staff recommends that DOE evaluate any new and significant information related to hydrogeological system uncertainty at INTEC and requests that DOE provide any recent reports or data related to hydrogeological system uncertainty at INTEC of which the NRC staff may not be cognizant.
2007-4	At the INL INTEC TFF, the NRC staff recommends that DOE provide information on any violations of requirements related to workers and the general public (10 CFR Part 835, "Occupational Radiation Protection," or DOE Order 5400.5, "Radiation Protection of the Public and the Environment," Change 2 (DOE, 1993)) during its waste disposal operations. As information provided on the Web may not be timely, the NRC staff requests that DOE provide information regarding worker or public dose exceedances within a reasonable time after their occurrence.
2007-5	At the INL INTEC TFF, the NRC staff recommends that DOE document deviations from assumptions made in its final waste determination and PA and assess the risk significance of these deviations.
2007-6	At the INL INTEC TFF, the NRC staff recommends that DOE consider whether specific additional requirements should be added to its contractor quality assurance program to address nonstandard grout characteristics that are relied on in the PA.
2007-7	In general, the NRC staff recommends that DOE consider performing engineering calculations before tank grouting at other DOE sites so that steps can be taken to limit temperature gradients and the potential for crack formation.

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6. GLOSSARY

closed activity—A monitoring activity for which a key assumption made or key parameter used by the U.S. Department of Energy (DOE) in its assessment has been either substantiated or determined not to be important in meeting the performance objectives of Subpart C, "Performance Objectives," of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste."

factor—An assumption made or a parameter used by DOE in its performance demonstration that the NRC has determined to be important through the review of a DOE waste determination, which describes its waste disposal actions and demonstrates that there is reasonable assurance that the performance objectives listed in 10 CFR Part 61, Subpart C, will be met.

highly radioactive radionuclides—Those radionuclides that contribute most significantly to risk to the public, workers, and the environment.

key monitoring area—An area that the U.S. Nuclear Regulatory Commission (NRC) has determined, through the review of a DOE waste determination that describes its waste disposal actions, to be important to demonstrating reasonable assurance that the performance objectives listed in 10 CFR Part 61, Subpart C, will be met.

monitoring activities—NRC and State activities to monitor DOE disposal actions to assess compliance with the performance objectives listed in 10 CFR Part 61, Subpart C.

noncompliance—A conclusion that DOE disposal actions will not be in compliance with the performance objectives of 10 CFR Part 61, Subpart C, or that there is an insufficient basis to assess whether the DOE waste disposal action will result in compliance with the performance objectives.

open activity—Monitoring activity that has not been closed and for which sufficient information has not been obtained to fully assess compliance with a 10 CFR Part 61, Subpart C, performance objective.

open issue—An issue that arises during monitoring activities that requires additional follow-up by the NRC staff or additional information from DOE to address questions that the NRC staff has raised regarding DOE disposal actions.

open-noncompliant activity—An ongoing monitoring activity that has provided evidence that the performance objectives of 10 CFR Part 61, Subpart C, are currently not being met or will not be met in the future or for which insufficient technical bases have been provided to determine that the performance objectives will be met.

operations—The timeframe during which DOE carries out its waste disposal actions through the end of the institutional control period. For the purpose of this plan, DOE actions involving waste disposal are considered to include performance assessment development (analytical modeling), waste removal, grouting, stabilization, observation, maintenance, or other similar activities.

performance assessment—A type of systematic (risk) analysis that addresses (1) what can happen, (2) how likely it is to happen, (3) what the resulting impacts are, and (4) how these impacts compare to specifically defined standards.

performance objectives—The NRC 10 CFR Part 61, Subpart C, requirements for low-level waste disposal facilities that include protection of the general population from releases of radioactivity (10 CFR 61.41), protection of individuals from inadvertent intrusion (10 CFR 61.42), protection of individuals during operations (10 CFR 61.43), and stability of the disposal site after closure (10 CFR 61.44).

recommendations—As used in this report, suggestions to DOE that address ways in which DOE can make progress in closing any open activities in the staff's monitoring plan; a monitoring area for which an open issue has been previously identified and closed and for which the NRC staff suggests further action to strengthen some aspect of the DOE disposal action; and monitoring areas where no open issues or concerns were previously raised but the NRC staff recommends further improvements to DOE disposal actions.

waste determination—DOE documentation demonstrating that a specific waste stream is not high-level waste (also known as non-high-level waste determination).

worker—DOE personnel or contractors who carry out operational activities at the disposal facility. For the purpose of this plan, 10 CFR Part 835, "Occupational Radiation Protection," dose limits (comparable to those in 10 CFR Part 20, "Standards for Protection against Radiation") would apply for radiation workers.

APPENDIX A: NATIONAL DEFENSE AUTHORIZATION ACT

Section 3116, Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005

SEC. 3116. DEFENSE SITE ACCELERATION COMPLETION.

(a) IN GENERAL—Notwithstanding the provisions of the Nuclear Waste Policy Act of 1982, the requirements of section 202 of the Energy Reorganization Act of 1974, and other laws that define classes of radioactive waste, with respect to material stored at a Department of Energy site at which activities are regulated by a covered State pursuant to approved closure plans or permits issued by the State, the term "high-level radioactive waste" does not include radioactive waste resulting from the reprocessing of spent nuclear fuel that the Secretary of Energy (in this section referred to as the "Secretary"), in consultation with the Nuclear Regulatory Commission (in this section referred to as the "Commission"), determines—

(1) does not require permanent isolation in a deep geologic repository for spent fuel or high-level radioactive waste;

(2) has had highly radioactive radionuclides removed to the maximum extent practical; and

(3)(A) does not exceed concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, and will be disposed of—

(i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations; and

(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; or

(B) exceeds concentration limits for Class C low-level waste as set out in section 61.55 of title 10, Code of Federal Regulations, but will be disposed of—

(i) in compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations;

(ii) pursuant to a State-approved closure plan or State-issued permit, authority for the approval or issuance of which is conferred on the State outside of this section; and

(iii) pursuant to plans developed by the Secretary in consultation with the Commission.

(b) MONITORING BY NUCLEAR REGULATORY COMMISSION—(1) The Commission shall, in coordination with the covered State, monitor disposal actions taken by the Department of Energy pursuant to subparagraphs (A) and (B) of subsection (a)(3) for the purpose of assessing compliance with the performance objectives set out in subpart C of part 61 of title 10, Code of Federal Regulations.

(2) If the Commission considers any disposal actions taken by the Department of Energy pursuant to those subparagraphs to be not in compliance with those performance objectives, the Commission shall, as soon as practicable after discovery of the noncompliant conditions, inform the Department of Energy, the covered State, and the following congressional committees:

(A) The Committee on Armed Services, the Committee on Energy and Commerce, and the Committee on Appropriations of the House of Representatives.

(B) The Committee on Armed Services, the Committee on Energy and Natural Resources, the Committee on Environment and Public Works, and the Committee on Appropriations of the Senate.

(3) For fiscal year 2005, the Secretary shall, from amounts available for defense site acceleration completion, reimburse the Commission for all expenses, including salaries, that the Commission incurs as a result of performance under subsection (a) and this subsection for fiscal year 2005. The Department of Energy and the Commission may enter into an interagency agreement that specifies the method of reimbursement. Amounts received by the Commission for performance under subsection (a) and this subsection may be retained and used for salaries and expenses associated with those activities, notwithstanding section 3302 of title 31, United States Code, and shall remain available until expended.

(4) For fiscal years after 2005, the Commission shall include in the budget justification materials submitted to Congress in support of the Commission budget for that fiscal year (as submitted with the budget of the President under section 1105(a) of title 31, United States Code) the amounts required, not offset by revenues, for performance under subsection (a) and this subsection.

(c) INAPPLICABILITY TO CERTAIN MATERIALS—Subsection (a) shall not apply to any material otherwise covered by that subsection that is transported from the covered State.

(d) COVERED STATES—For purposes of this section, the following States are covered States:

(1) The State of South Carolina.

(2) The State of Idaho.

(e) CONSTRUCTION—(1) Nothing in this section shall impair, alter, or modify the full implementation of any Federal Facility Agreement and Consent Order or other applicable consent decree for a Department of Energy site.

(2) Nothing in this section establishes any precedent or is binding on the State of Washington, the State of Oregon, or any other State not covered by subsection (d) for the management, storage, treatment, and disposition of radioactive and hazardous materials.

(3) Nothing in this section amends the definition of “transuranic waste” or regulations for repository disposal of transuranic waste pursuant to the Waste Isolation Pilot Plant Land Withdrawal Act or part 191 of title 40, Code of Federal Regulations.

(4) Nothing in this section shall be construed to affect in any way the obligations of the Department of Energy to comply with section 4306A of the Atomic Energy Defense Act (50 U.S.C. 2567).

(5) Nothing in this section amends the West Valley Demonstration Act (42 U.S.C. 2121a note).

(f) JUDICIAL REVIEW—Judicial review shall be available in accordance with chapter 7 of title 5, United States Code, for the following:

(1) Any determination made by the Secretary or any other agency action taken by the Secretary pursuant to this section.

(2) Any failure of the Commission to carry out its responsibilities under subsection (b).

APPENDIX B: MONITORING SUMMARY TABLES

Summary Tables of U.S. Nuclear Regulatory Commission Monitoring Plans

Table 1: Monitoring at Savannah River Site Saltstone Facilities (NRC, 2007b)

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
61.41	Data review		Review information on reported inventories and concentrations in the Saltstone Disposal Facility. (SRS-SLT-41-00-01-T)	T	Open
			Review ground water monitoring data, updates to the monitoring plan, and quality assurance plans for sampling. (SRS-SLT-41-00-02-T)	T	Open
	Factor 1, Oxidation of Saltstone	The rate of waste oxidation is a key factor in the future performance of the Saltstone Disposal Facility because the release of technetium is very dependent on the extent of oxidation of the saltstone wasteform. Realistic modeling of waste oxidation is needed to assure that the performance objectives of Title 10 of the *Code of Federal Regulations*	Review information on vault design as it relates to oxidation. (SRS-SLT-41-01-01-T)	T	Open
			Review information on gas phase transport of oxygen within the saltstone. (SRS-SLT-41-01-02-T)	T	Open
			Review field and laboratory experiments and any additional modeling of saltstone oxidation and technetium release. (SRS-SLT-41-01-03-T)	T	Open

1 There are two main types of monitoring activities: T=technical review activities; O=onsite observation activities.

2 The activities are tracked as open, open-noncompliant, or closed. The glossary defines these terms.

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
		(10 CFR) 61.41, "Protection of the General Population from Releases of Radioactivity," will be met. Adequate model support is essential to providing the technical basis for the model results.	Review information on grout formulation and grout curing conditions. (SRS-SLT-41-01-04-O)	O	Open
61.41 (cont.)	Factor 1, Oxidation of Saltstone (cont.)		Evaluate the adequacy of the U.S. Department of Energy (DOE) program for verifying the specifications of blast furnace slag. (SRS-SLT-41-01-05-O)	O	Open
	Factor 2, Hydraulic Isolation of Saltstone	To better understand the future performance of the disposal facility, it is important to understand the mechanisms of degradation of the wasteform to predict the rate of degradation, as well as the expected physical properties of the degraded wasteform, such as hydraulic conductivity and diffusivity.	Review information to support the exclusion from consideration of specific saltstone degradation mechanisms. (SRS-SLT-41-02-01-T)	T	Open
			Review information on curing technique and curing time for grout and concrete. (SRS-SLT-41-02-02-T)	T	Open
			Review information on water condensation within the vaults. (SRS-SLT-41-02-03-T)	T	Open
			Review information on the dissolution of salts and low-solubility matrix phases within the grout. (SRS-SLT-41-02-04-T)	T	Open
			Observe vault construction and performance. (SRS-SLT-41-02-05-O)	O	Open

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
61.41 (cont.)	Factor 3, Model Support	Adequate model support is essential to assessing whether the saltstone disposal facility can meet the requirements of 10 CFR 61.41. The model support for the following items is key to confirming the performance assessment results: (1) moisture flow through fractures in the concrete and saltstone located in the vadose zone, (2) realistic modeling of waste oxidation and release of technetium, (3) the extent and frequency of fractures in saltstone and vaults that will form over time, (4) the plugging rate of the lower drainage layer of the engineered cap, and (5) the long-term performance of the engineering cap as an infiltration barrier.	Review any new moisture characteristic data for concrete and saltstone. (SRS-SLT-41-03-01-T)	T	Open
			Review available information on the rate of equilibrium of water content within the saltstone. (SRS-SLT-41-03-02-T)	T	Open
			Review any additional modeling analysis of moisture flow in the saltstone. (SRS-SLT-41-03-03-T)	T	Open
			Review DOE conceptual model for oxidation and technetium release and any support for the model. (SRS-SLT-41-03-04-T)	T	Open
			Review laboratory and field studies on concrete and saltstone cracking. (SRS-SLT-41-03-05-T)	T	Open
			Observe any experiments performed to address issues related to Factor 3. (SRS-SLT-41-03-06-O)	O	Open
61.42	Factor 4, Erosion Control Design	Implementation of an adequate erosion control design is important to ensuring that the provisions of 10 CFR 61.42, "Protection of Individuals from Inadvertent	Evaluate technical details of the proposed closure cap. (SRS-SLT-42-04-01-T)	T	Open
			Evaluate the design of erosion control features. (SRS-SLT-42-04-02-T)	T	Open

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
		Intrusion," can be met. The erosion control barrier will help to maintain a thick layer of soil over the vaults, which reduces the potential for intrusion into the waste.	Evaluate updates or revisions to DOE intruder analysis. (SRS-SLT-42-04-03-T)	T	Open
61.41	Factor 5, Infiltration Barrier Perf.	The design and performance of the infiltration control system is important for ensuring that the requirements of 10 CFR 61.41 can be met The release of contaminants from the saltstone to the ground water is predicted to be sensitive to the amount of infiltration.	Review experiments and field studies that simulate processes related to plugging of the drainage layer through colloidal clay migration. (SRS-SLT-41-05-01-T)	T	Open
			Review any experiments, analyses, or expert elicitation regarding the long-term performance of the infiltration barrier. (SRS-SLT-41-05-01-T)	T	Open
	Factor 6, Feed Tank Sampling	Implementation of an adequate waste sampling plan is important to ensuring that the provisions of 10 CFR 61.41 and 10 CFR 61.42 can be met. It is necessary to confirm that the concentration of highly radioactive radionuclides (HRRs) in treated salt waste (or grout) is less than or equal to the concentration assumed in the waste determination.	Review DOE waste sampling plan and quality assurance procedures for sampling waste. (SRS-SLT-41-06-01-T)	T	Open
			Review waste sampling data for the feed tank (Tank 50). (SRS-SLT-41-06-02-T)	T	Open
			Observe waste sampling activities. (SRS-SLT-41-06-03-O)	O	Open
61.41 (cont.)	Factor 7, Tank 48	The chemical composition of the salt waste in Tank 48 differs from	Review DOE approach for treating waste in Tank 48. (SRS-SLT-41-07-01-T)	T	Open

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
	Wasteform	the salt waste in other tanks because it contains a substantial amount of organic salts. To ensure that Tank 48 waste can be safely managed, tests are needed to measure the physical properties of the wasteform made from this waste to confirm that it will provide suitable performance.	Review characterization information for Tank 48. (SRS-SLT-41-07-02-T)	T	Open
			Review information on the expected physical properties of the Tank 48 wasteform. (SRS-SLT-41-07-03-T)	T	Open
61.41 (cont.)	Factor 8, Removal Efficiencies	The removal efficiencies of HRRs by each of the planned salt waste treatment processes are a key factor in determining the radiological inventory disposed of in saltstone, which, in turn, is an important factor in determining that 10 CFR 61.41 and 10 CFR 61.42 can be met.	Review information on radionuclide removal efficiencies by the various treatment processes. (SRS-SLT-41-08-01-T)	T	Open
			Review estimates of the amount of sludge entrained in the salt waste during the deliquification, dissolution, and adjustment process. (SRS-SLT-41-08-02-T)	T	Open
			Evaluate updates or revisions to DOE performance assessment (PA) and special analysis. (SRS-SLT-41-08-03-T)	T	Open
61.43	Radiation Protection and Environ-mental Protection		Review reports related to worker and general public doses. (SRS-SLT-43-RE-01-T)	T	Open
			Review air effluent data from the salt waste processing facility. (SRS-SLT-43-RE-02-T)	T	Open

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
			Review information on DOE quality assurance program for monitoring air emissions. (SRS-SLT-43-RE-03-T)	T	Open
			Review DOE radiation protection program. (SRS-SLT-43-RE-04-O)	O	Open
			Observe DOE process for obtaining air effluent data. (SRS-SLT-43-RE-05-O)	O	Open
			Review DOE ground water sampling process and installation of new wells. (SRS-SLT-43-RE-06-O)	O	Open
61.44			Observe the disposal facility for obvious signs of degeneration. (SRS-SLT-44-XX-01-O)	O	Open

Table 2: Monitoring at Idaho National Laboratory Idaho Nuclear Technology and Engineering Center Tank Farm Facility (NRC, 2007a)

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
61.41	KMA 1, Residual Waste Sampling	DOE should sample tanks WM-187 through WM-190 after cleaning, as stated in Section 2.3 of the Draft Section 3116 Determination Idaho Nuclear Technology and Engineering Center Tank Farm Facility (DOE, 2005). After cleaning, DOE should review sampling data and analysis of tanks WM-187 through WM-190 to ensure that the inventory for these tanks is not significantly underestimated (i.e., similar or better waste retrieval will be achieved).	Review sampling and analysis plans (SAPs) and data quality assessments for tanks WM-187 through WM-190. (INL-TFF-41-01-01-T)	T	Open
			Compare postcleaning WM-182 tank inventory to postcleaning tank inventories developed for WM-187 through WM-190. (INL-TFF-41-01-02-T)	T	Open
			Compare vault WM-187 liquid sampling to vault WM-185 liquid sampling. (INL-TFF-41-01-03-T)	T	Open
			Observe postcleaning sampling of tanks WM-187 through WM-190 against the SAP. (INL-TFF-41-01-04-O)	O	Open
			Observe use of video equipment to map out waste residual depths in the cleaned tanks to estimate waste residual volumes. (INL-TFF-41-01-05-O)	O	Open

1 There are two main types of monitoring activities: T=technical review activities; O=onsite observation activities.

2 The activities are tracked as open, open-noncompliant, or closed. The glossary defines these terms.

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
61.42	KMA 1, Residual Waste Sampling (cont.)		Compare postcleaning WM-182 tank inventory to the postcleaning tank inventories developed for WM-187 through WM-190. (INL-TFF-42-01-06-T)	T	Open
61.41	KMA 2, Grout Formulation and Perf.	The final grout formulation used to stabilize the Idaho Nuclear Technology and Engineering Center (INTEC) Tank Farm Facility (TFF) waste should be consistent with design specifications, or significant deviations should be evaluated to ensure that they will not negatively impact the expected performance of the grout. The reducing capacity of the tank grout is important to mitigating the release of technetium-99. Short-term performance of as-emplaced grout should be similar to or better than that assumed in the Performance Assessment (PA) release modeling, or significant deviations should be evaluated to determine their significance with respect to the conclusions in the PA and technical evaluation report (TER). The short-term performance of the grouted vault is especially important to mitigate the release of short-lived radionuclides, such as strontium-90, from the contaminated sand pads that could potentially dominate the predicted doses from the TFF within the first few hundred years.	Determine whether the vendor-supplied slag has sufficient sulfide content to maintain reducing conditions in the tank grout. (INL-TFF-41-02-01-T)	T	Open
			Determine whether slag storage is sufficient to maintain the quality and chemical reactivity of the slag. (INL-TFF-41-02-02-T)	T	Closed
			Assess the short-term performance of the as-emplaced grout. (INL-TFF-41-02-03-T)	T	Open
			Evaluate the final grout formulation for consistency with design specifications. (INL-TFF-41-02-04-O)	O	Open
			Evaluate the risk significance of any deviations in the final grout formulation from design specifications. (INL-TFF-41-02-05-O)	O	Open

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
61.41 (cont.)	KMA 2, Grout Formulation and Perf. (cont.)		Evaluate the DOE program for sampling, testing, and accepting grout materials. (INL-TFF-41-02-06-O)	O	Closed
			Verify conditions of grout placement in terms of temperature and humidity. (INL-TFF-41-02-07-O)	O	Closed
61.44			Review information on grout formulation, placements, and pours. (INL-TFF-44-02-08-T)	T	Open
61.41	KMA 3, Hydrologic Uncertainty	Relevant recent and future monitoring data and modeling activities should continue to be evaluated to ensure that hydrological uncertainties that may significantly alter the conclusions in the PA are addressed. If significant new information is found, it should be evaluated against the PA and TER conclusions.	Evaluate and assess the risk significance of any variations in DOE PA-predicted natural attenuation of strontium-90 through the vadose zone. (INL-TFF-41-03-01-T)	T	Open
			Evaluate and assess the risk significance of any increased estimates of infiltration rates at the INTEC TFF above those assumed in the DOE PA. (INL-TFF-41-03-02-T)	T	Open
			Review hydrological studies and monitoring data for new and significant information related to natural attenuation at the INTEC TFF. (INL-TFF-41-03-03-T)	T	Open

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
61.43	KMA 4, Monitoring during Operations	Closure and postclosure operations (until the end of active institutional controls, which is 100 years) will be monitored to ensure that the performance objective in 10 CFR 61.43, "Protection of Individuals during Operations," can be met.	Review DOE Idaho radiation protection program to ensure that it is consistent with that described in its waste determination. (INL-TFF-43-04-01-T)	T	Open
			Review pathway analysis, environmental data collected, and DOE estimate of doses to members of the public. (INL-TFF-43-04-02-T)	T	Open
			Observe risk-significant DOE closure activities. (INL-TFF-43-04-03-O)	O	Open
			Observe air sampling activities and DOE meteorological program or rely on Idaho Department of Environmental Quality (DEQ) environmental surveillance program.[3] (INL-TFF-43-04-04-O)	O	Open

[3] As noted in the body of the report, the U.S. Nuclear Regulatory Commission (NRC) relies on the Idaho DEQ environmental surveillance program for this monitoring activity.

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
61.41	KMA 5, Engineered Surface Barrier/ Infiltration Reduction	INTEC infiltration controls and the construction and maintenance of an engineered cap over the TFF under the Comprehensive Environmental Response, Compensation, and Liability program should be monitored to ensure that the PA assumptions related to infiltration and contaminant release are bounding.	Evaluate and assess the design, construction, maintenance, and as-emplaced performance of engineered barriers installed at the INTEC TFF against DOE PA assumptions regarding infiltration. (INL-TFF-41-05-01-T)	T	Open
61.41	KMA 5, Engineered Surface Barrier/ Infiltration Reduction (cont.)		Remain cognizant of any changes to the preliminary design of the infiltration-reducing cap. (INL-TFF-41-05-02-O)	O	Open
			Observe maintenance activities of the cap. (INL-TFF-41-05-03-O)	O	Open
61.41	Update Perf. Assessment	DOE Order 435.1, "Radioactive Waste Management," requires that the DOE PA be reviewed and revised when there are changes in wasteform or containers, radionuclide inventories, facility design or operation, or closure concepts or there is an improved understanding of facility performance.	Review any revisions and updates to the DOE PA model to assess the impact of changes on conclusions regarding compliance with the performance objectives. (INL-TFF-41-PA-01-T)	T	Open

10 CFR Part 61 Performance Objectives	Monitoring Area	Description	Activities		
			Monitoring Activity Code	Type[1]	Status[2]
61.41	Environmental Review and Environmental Sampling		Review analytical data on perched and saturated ground water at the INTEC TFF. (INL-TFF-41-RE-01-T)	T	Open
			Review hydrological studies relevant to flow and transport at the INTEC TFF. (INL-TFF-41-RE-02-T)	T	Open
61.41 and 61.43	Environmental Review and Environmental Sampling (cont.)		Observe the installation of monitoring wells and instrumentation. (INL-TFF-41-RE-03-O)	O	Open
			Observe sampling activities. or Rely on Idaho DEQ oversight program.[4] (INL-TFF-41-RE-04-O)	O	Open
61.44	N/A		Observe signs of system failure. (INL-TFF-44-XX-01-O)	O	Open
			Observe system performance after extreme events. (INL-TFF-44-XX-02-O)	O	Open

4 As noted in the body of the report, the NRC relies on the Idaho DEQ environmental surveillance program for this monitoring activity.

References

U.S. Department of Energy. DOE/NE–ID–11226, “Draft Section 3116 Determination Idaho Nuclear Technology and Engineering Center Tank Farm Facility–Draft.” Rev. 0. Idaho Falls, ID: DOE Idaho. September 2005.

U.S. Department of Energy. DOE Order 435.1, “Radioactive Waste Management.” Washington, DC: DOE. August 2001.

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U.S. Department of Energy. DOE/NE–ID–11226, "Draft Section 3116 Determination Idaho Nuclear Technology and Engineering Center Tank Farm Facility–Draft." Rev. 0. Idaho Falls, ID: DOE Idaho. September 2005.

U.S. Department of Energy. DOE Order 435.1, "Radioactive Waste Management." Washington, DC: DOE. August 2001.

APPENDIX C: 2009 OBSERVATION REPORTS

U.S. Nuclear Regulatory Commission Observation Reports for Calendar Year 2009

May 22, 2009

Mr. Thomas Gutmann, Director
Waste Disposition Programs Division
U.S. Department of Energy
Savannah River Operations Office
P.O. Box A
Aiken, SC 29802

SUBJECT: NUCLEAR REGULATORY COMMISSION MARCH 25-26, 2009 ONSITE OBSERVATION REPORT FOR THE SAVANNAH RIVER SITE SALTSTONE FACILITY

Dear Mr. Gutmann:

The enclosed report describes the U.S. Nuclear Regulatory Commission's (NRC's) onsite observation activities on March 25-26, 2009, at the Savannah River Site (SRS) Saltstone Facility. This onsite observation was conducted in accordance with Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (Section 3116), which requires NRC to monitor disposal actions taken by DOE for the purpose of assessing compliance with the performance objectives set out in 10 CFR Part 61, Subpart C. The activities conducted during the site visit were consistent with those described in the NRC's monitoring plan for salt waste disposal at SRS (dated May 3, 2007) and NRC's staff guidance for activities related to waste determinations (NUREG-1854, dated August, 2007).

Similar to NRC's previous visits, this onsite observation at SRS was primarily focused on assessing compliance with two performance objectives, 10 CFR 61.41, protection of the general population from releases of radioactivity, and 10 CFR 61.43, protection of individuals during operations, by observing DOE's ongoing construction of disposal cells at the Saltstone Disposal Facility (SDF), requesting additional information about the methods used by DOE to estimate the inventory of radionuclides in the SDF, and discussing staff questions and comments on 10 of 14 technical reports provided to NRC since November 2008. Since the quality of saltstone grout is relevant to the long-term stability of the disposal facility after its closure, this observation also partially assessed the performance objective in 10 CFR 61.44, stability of the disposal site after closure.

One new open issue was identified by NRC staff, in which staff determined that DOE should provide additional support for assumptions that: (1) technetium-99 in salt waste is converted to its reduced chemical form in saltstone grout during the curing of saltstone grout, and is thereby strongly retained in saltstone grout, and (2) the sorption of dissolved technetium-99 onto saltstone grout and vault concrete is consistent with Kd values for technetium-99 that were assumed in the performance assessment. NRC and DOE staff also identified 21 DOE follow-up actions, which are mostly in response to NRC staff questions on 10 of 14 technical reports, which DOE provided to NRC staff since November 2008. NRC staff will continue its reviews of these reports, pending DOE responses to the follow-up actions identified in the attached report.

Based on our observations, NRC continues to conclude that there is reasonable assurance that the applicable criteria of Section 3116 can be met if key assumptions made in DOE's waste determination analyses prove to be correct. In accordance with the requirements of Section 3116 and consistent with NRC's monitoring plan for the salt waste disposal facility, NRC will continue to monitor DOE's disposal actions at SRS. The monitoring activities are expected to be an iterative process. Several onsite observation visits and technical reviews may be necessary in order to obtain the information needed to close all of the current open issues, as well as issues that may be opened in the future.

On March 26, 2009, at the conclusion of the onsite observation activities, NRC staff members discussed the topics addressed in this report with you, other DOE representatives, and representatives from the State of South Carolina. If you have any questions or need additional information regarding this report, please contact David Brown of my staff at (301) 415-6116.

Sincerely,

/RA/

Patrice Bubar, Deputy Director
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

Enclosure:
NRC Observation Report

cc: w encl:
S. Wilson
Federal Facilities Liaison
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2600 Bull Street
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NUCLEAR REGULATORY COMMISSION MARCH 25-26, 2009 ONSITE OBSERVATION REPORT FOR THE SAVANNAH RIVER SITE SALTSTONE FACILITY

EXECUTIVE SUMMARY

The Nuclear Regulatory Commission staff conducted its fourth onsite observation visit of the Saltstone Facility at the Savannah River Site (SRS) on March 25-26, 2009. This visit was intended to focus on two of the four performance objectives—10 CFR 61.41, "*protection of the general population from releases of radioactivity*", and 10 CFR 61.43, "*protection of individuals during operations*"—by obtaining information on The U.S. Department of Energy (DOE) saltstone wasteform production and saltstone disposal facility operations and verifying DOE's radiation protection measures for relevant operations. Because the saltstone wasteform production operations could impact the long-term stability of the disposal facility after its closure, this observation also was intended to partially assess compliance with the performance objective in 10 CFR 61.44, *stability of the disposal site after closure*. This report provides a description of NRC onsite observation activities and identifies NRC observations from the visit. Based on the results of the visit, the NRC continues to have reasonable assurance that the performance objectives of 10 CFR 61 can be met in the areas reviewed.

There is one new open issue as a result of the staff's ongoing technical reviews of 14 technical reports provided to NRC staff since November 2008, which was discussed with observation participants on March 26. In Open Issue 2009-1, staff has determined that DOE should provide additional support for assumptions that: (1) technetium-99 in salt waste is converted to its reduced chemical form in saltstone grout during the curing of saltstone grout, and is thereby strongly retained in saltstone grout, and (2) the sorption of dissolved technetium-99 onto saltstone grout and vault concrete is consistent with Kd values for technetium-99 that were assumed in the performance assessment. A summary of the staff's other observations and conclusions is provided below:

Disposal Cell Construction

- The staff observed ongoing construction at Saltstone Disposal Facility Cells 2A and 2B. At the time of the staff's visit, the base mud mat, geosynthetic clay liner and 100-mil high-density polyethylene liner, Type V mud mat and floor had been installed for Cells 2A and 2B, and the floor was curing. Rebar pedestals had been cast in place for the 48 columns that will support the roof in each cell. Forms were installed at several locations on the ground outside the cells for casting 32 15-ton wall panels for each cell, but no wall panels had been cast. DOE has two follow-up actions from this activity relating to NRC staff requests for (i) photographs of construction joints that will be covered by successive layers of construction material before NRC staff can return to directly observe the joints, and (ii) construction design drawings.

Saltstone Radionuclide Inventory

- The staff discussed with DOE and DOE contractor staff the assumptions and data used to quantify the inventory of radionuclides in liquid waste that is transferred to the SDF. DOE has three follow-up actions pertaining to NRC staff requests for additional information that supports the quarterly Saltstone Permit Reports published on the DOE Savannah River Operations office website.

Ongoing NRC Staff Technical Reviews

- The NRC staff discussed with DOE and DOE contractor staff 10 of 14 technical reports provided to NRC staff since November 2008. These reports covered the results of studies on soil contamination in the vicinity of Vault 4 and the results of physical and chemical studies on both actual disposal cells (e.g., video of Vault 4, Cell G), and laboratory-prepared saltstone grout and vault concrete. Aside from the open issue described above, DOE has 16 follow-up actions related to staff questions on these studies.

1.0 BACKGROUND

Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (Section 3116) authorizes the DOE, in consultation with the NRC, to determine that certain radioactive waste related to the reprocessing of spent nuclear fuel is not high-level waste, provided certain criteria are met. Section 3116 also requires NRC to monitor DOE disposal actions to assess compliance with the performance objectives in 10 CFR Part 61, Subpart C.

On March 31, 2005, DOE submitted a "Draft Section 3116 Determination, Salt Waste Disposal Savannah River Site" to demonstrate compliance with the Section 3116 criteria including demonstration of compliance with the performance objectives in 10 CFR Part 61, Subpart C (DOE, 2005). In its consultation role, the NRC staff reviewed the draft waste determination and concluded that there was reasonable assurance that the applicable criteria of Section 3116 could be met, provided certain assumptions made in DOE's analyses are verified via monitoring. NRC documented the results of its review in a technical evaluation report (TER) issued in December 2005 (NRC, 2005). DOE issued a final waste determination in January 2006 taking into consideration the assumptions, conclusions, and recommendations documented in NRC's TER (DOE, 2006).

To carry out its monitoring responsibility under Section 3116, NRC plans to perform three types of activities: (i) technical reviews, (ii) onsite observations, and (iii) data reviews. These activities will focus on key assumptions—called "factors"—identified in the NRC monitoring plan for saltwaste disposal at SRS (NRC, 2007). Technical reviews generally will focus on obtaining additional model support for assumptions DOE made in its performance assessment (PA) that are considered important to DOE's compliance demonstration. Onsite observations generally will be performed to (i) observe the collection of data (e.g., observation of waste sampling used to generate radionuclide inventory data) and review the data to assess consistency with assumptions made in the waste determination, or (ii) observe key disposal (or closure) activities related to technical review areas (e.g., slag and other material storage, grout formulation and preparation, and grout placements). Data reviews will supplement technical reviews by focusing on monitoring data that may also indicate future system performance or by reviewing records or reports that can be used to directly assess compliance with performance objectives.

On March 25-26, 2009, the NRC staff onsite observation visit at SRS focused primarily on two performance objectives, 10 CFR 61.41, *protection of the general population from releases of radioactivity*, and 10 CFR 61.43, *protection of individuals during operations*, by observing DOE's ongoing construction of disposal cells at the Saltstone Disposal Facility (SDF), requesting additional information about the methods used by DOE to estimate the inventory of radionuclides in the SDF, and discussing staff questions and comments on 10 of 14 technical reports provided to NRC since November 2008. Because the vaults and saltstone grout could impact the long-term stability of the disposal facility after its closure, this observation also was intended to partially assess compliance with the performance objective in 10 CFR 61.44, *stability of the disposal site after closure*. Future visits will assess the performance objective in 10 CFR 61.42, *protection of individuals against inadvertent intrusion*, and also continue to assess DOE compliance with the other performance objectives.

Saltstone Facility Operational Status at the time of the Observation

At the request of NRC staff, DOE and DOE contractor staff provided a brief overview of operations at the Saltstone Facility since the last onsite observation (NRC, 2008). DOE explained that salt waste in Tank 50 was not processed at the SPF between April 2008 and December 2008. In January, the transfer of material from Tank 50 to the SPF resumed. In addition, batch 1 of salt waste in Tank 49 was treated at the Actinide Removal Process/Modular Caustic Side Solvent Extraction process (ARP/MCU) through September 2008. Batch 2 of ARP/MCU feed was qualified in November and December 2008, with approximately 70,000 gallons of batch 2 waste having since been sent to ARP/MCU for treatment.

2.0 NRC ONSITE OBSERVATION ACTIVITIES

2.1 Disposal Cell Construction

NRC staff monitors ongoing construction of disposal cells, as described in section 3.2.3, "Vault Construction," of the staff's monitoring plan (NRC, 2007).

2.1.1 Observation Scope

The general purpose of NRC staff observations of ongoing construction of Saltstone Disposal Facility Cells 2A and 2B is to identify noticeable deviations from the vault design,ocusing on changes that could affect potential pathways for water to intrude into the vaults, such as penetrations or joints. A specific objective of this monitoring visit was to become familiar with the construction area and methods being used to construct new disposal cells.

2.1.2 Observation Results

The staff observed ongoing construction at Saltstone Disposal Facility Cells 2A and 2B. At the time of the staff's visit, the base mud mat, geosynthetic clay liner and 100-mil high-density polyethyline liner, Type V mud mat and floor had been installed for Cells 2A and 2B, and the Type V concrete floor was curing under plastic covers. Rebar pedestals had been cast in place in the floor for the 48 columns that will support the roof in each cell. Forms were constructed at various locations on the ground outside the cells for casting 32 15-ton wall panels for each cell, but no wall panels had been cast at the time of the observation.

2.1.3 Conclusions and Followup Actions

No issues or concerns were identified during the observation of disposal cell construction. Staff plans to return to the site in late May or June 2009 to observe installation of wall panels. In the interim, DOE agreed to take photographs of construction joints, prior to covering the joints with additional construction layers or concrete. At NRC staff's request, DOE will provide a complete set of Vault 2 design drawings. NRC staff will provide specific requests for construction photographs to DOE after reviewing the drawings.

DOE Follow-up Actions

1. DOE agreed to take photographs of construction joints, prior to covering the joint with additional construction layers or concrete.

2. At NRC staff's request, DOE will provide a complete set of Vault 2 design drawings.
Action 2 complete: see NRC, 2009

2.2 Saltstone Radionuclide Inventory

NRC staff monitors feed tank sampling and waste sampling, as described in section 3.1.1, "Data Reviews," section 3.1.6., "Factor 6--Feed Tank Sampling," section 3.2.2., "Waste Sampling," and section 3.1.8, "Factor 8—Removal Efficiencies," of the staff's monitoring plan (NRC, 2007).

2.2.1. Observation Scope

NRC staff interviewed DOE and DOE contractor staff on topics related to liquid waste sampling and tracking of the radionuclide inventory transferred to the SDF during this onsite observation visit. The purpose of the interviews was to better understand and evaluate the methods used by DOE to quantify the inventory of radionuclides in liquid waste that is transferred to the SDF. This review was performed as part of the evaluation of Factor 6, Feed Tank Sampling, and Factor 8, Removal Efficiencies, identified in the NRC monitoring plan (NRC, 2007). Adequate characterization of the liquid waste transferred to the SDF is important because the total inventory of radionuclides disposed of in the SDF affects whether the performance objectives of 10 CFR 61.41 can be met. The methods used for waste sampling and tracking of the radionuclide inventory transferred to the SPF/SDF were previously reviewed during the October 2007 and March 2008 onsite observation visits.

2.2.2 Observation Results

DOE contractor staff provided an explanation of the data and assumptions that are used to prepare quarterly Saltstone Permit Reports that are available on the DOE Savannah River Operations Office website. This included an explanation of how information from a Tank 50 material balance worksheet, and other supporting information, is used to estimate volume weighted concentrations of radionuclides that are sent to the SDF each quarter. NRC staff asked why quarterly totals of radionuclides in grout (calculated by multiplying the total amount of grout reported in the Saltstone Permit Reports by the volume weighted average concentration in grout reported for each radionuclide) did not match quarterly totals of radionuclides in liquid waste (similarly calculated by multiplying the total amount of liquid salt waste solidified at the SDF by the volume weighted average concentration in liquid salt waste reported for each radionuclide). DOE contractor staff explained that total quantities of grout reported in the Permit Reports include grout used to form cold caps, and that bleedwater and flushwater from the SDF and SPF, respectively, are seen by a grout line flow transmitter as "grout," even though these transfers would not add radionuclides to the SDF. As a result, the reported liquid salt waste concentrations and volumes are considered by DOE to be a more reliable basis for estimating quarterly radionuclide inventory in the SDF. In addition, DOE staff stated that the quarterly concentrations reported for the radionuclides that have "limits" set for them in the Saltstone WAC are based on volume weighted averages calculated based on the concentrations calculated in the materials balance worksheet. However, the quarterly concentrations reported for the radionuclides that have "target" acceptance criteria are based only on the concentration measured in a semi-annual sample.

NRC and DOE contractor staff also discussed how semi-annual Tank 50 confirmatory samples taken for measurements of radionuclide concentrations are used to adjust estimates of radionuclide inventory in Tank 50, which are more routinely updated using process knowledge and sampling results for influent liquid wastes to Tank 50.

NRC staff plan to continue monitoring the inventory of radionuclides being added to the SDF. DOE agreed to provide additional information that NRC staff plan to review, including documentation, such as the materials balance worksheets, that supports the calculations used to derive the inventory estimates provided in quarterly Saltstone Permit Reports from the third calendar quarter of 2007 through the second quarter of 2008. DOE will also evaluate Tank 50 sample results vs. the Tank 50 material balance to verify that the materials balance is able to accurately estimate the concentration of radionuclides in Tank 50. Observation participants also discussed ongoing operations under the ARP/MCU management control plan (MCP). Under the MCP, DOE continues to sample and hold each batch of salt waste to be processed by the ARP/MCU, pending results of sample analysis. Ultimately, DOE intends to change to a "sample and send" mode of operation, wherein waste is processed, even while sample results are pending. The "sample and send" mode will enable DOE to increase waste treatment throughput. DOE also is considering developing a statistical basis for sampling less frequently than every microbatch.

<u>DOE Follow-up Actions</u>

3. Provide sufficient documentation to support quarterly Saltstone Permit Reports for the period from third quarter 2007 through second quarter 2008.

4. Provide evaluation of Tank 50 material balance, from third quarter 2007 to present.

5. Inform NRC when DOE is ready to exit its ARP/MCU management control plan.

2.2.3 Conclusions and Followup Actions

There are no new open issues or recommendations resulting from staff observations at this time. DOE follow up actions are listed above.

2.3 Ongoing NRC Staff Technical Reviews

NRC staff continues to monitor the quality of saltstone grout and vault concrete, as described in section 3.1.2., "Factor 1—Oxidation of Saltstone," and section 3.1.3., "Factor 2 - Hydraulic Isolation of Saltstone," and section 3.1.4, "Factor 3 – Model Support," of the staff's monitoring plan (NRC, 2007).

2.3.1 Observation Scope

Observation participants discussed 10 of 14 technical reports provided to NRC staff since November 2008. The reports are listed in Table 1 below.

Table 1. Ongoing NRC staff technical reviews

No.	Description	ADAMS Accession No.
1	Rosenberger, K. H., *Comparison of Vault 4 Soil Sampling Results to Existing Unreviewed Disposal Question Evaluation SRS-REG-2007-00041*, SRNS-J2100-2008-00013, Savannah River Nuclear Solutions. December 3, 2008	ML090120429
2	Kubilius, W., *Z-area Vault 4 Phase 2 Soil Sample Analytical Data Report*, ERD-EN-2008-0083, Savannah River Site, December 2008.	ML090120404
3	Rosenberger, K. H., *Unreviewed Disposal Question Evaluation: Evaluation of Liquid Weeping from Saltstone Vault 4 Exterior Walls*, SRS-REG-2007-00041, Revision 1, Westinghouse Savannah River Company, Aiken, South Carolina, April 2008.	ML090120475
4	Kent, E., Letter to J. Buczek, WSRC, re: Samples received on February 14, 2008, GEL Laboratories, March 13, 2008.	ML090120546
5	Kent, E., Letter to J. Buczek, WSRC, re: Samples received on July 16, 2008, GEL Laboratories, September 16, 2008.	ML090120539
6	Kaplan, D. I., K. Roberts, J. Coates, M. Siegfried, S. Serkiz, *Saltstone and Concrete Interactions with Radionuclides: Sorption (Kd), Desorption, and Reduction Capacity Measurements*, SRNS-STI-2008-00045, Savannah River National Laboratory, WSRC. October 2008	ML090150234
7	Dixon, K., J. Harbour, and M. Phifer, *Hydraulic and Physical Properties of Saltstone Grouts and Vault Concretes*, SRNL-STI-2008-00421, Revision 0, Savannah River National Laboratory, WSRC. November 2008	ML090150298
8	Langton, C., *Evaluation of Sulfate Attack on Saltstone Vault Concrete and Saltstone, Part I: Final Report*, SRNS-STI-2008-00050, Revision 0, Savannah River National Laboratory, SRNS. August 19, 2008	ML090150306
9	Langton, C., *Evaluation of Sulfate Attack on Saltstone Vault Concrete and Saltstone, Part II: Test Methods to Support Moisture and Ionic Transport Modeling using the STADIUM® Code*, SRNS-STI-2008-00052, Revision 0, Savannah River National Laboratory, SRNS. August 19, 2008	ML090150312
14	Dixon, K., J., *Video Survey of Saltstone Vault 4, Cell G*, SRNL-ESB-2008-00017, Savannah River National Laboratory, WSRC. April 25, 2008	ML090150154

2.3.2 Observation Results

Summaries of the technical review discussions, including follow-up actions by DOE, are provided below.

Vault 4 soil sampling

Reports 1-5 listed above pertain to studies of soil contamination that occurred outside of Cell E of Vault 4 at the SDF as a result of active weep sites in the exterior vault wall. Of particular interest to NRC staff is the concentration of iodine-129 that was observed in one sample, as described in Section 4.3 of Report 2. The reported iodine-129 concentration in a phase 2 gravel sample from 3" to 12" in depth next to Cell E was 69 pCi/g (a 95 percent confidence interval, or uncertainty value, was not reported). The cesium-137 value for the corresponding phase 1 sample from the same depth and location was 11,700 pCi/g. Using these values, staff calculated a concentration ratio of Cs-137 to I-129 of about 170. Using expected SDF inventories cited in the salt waste performance assessment (DOE, 2005), the expected average Cs-137:I-129 ratio in salt waste is about 75,000. NRC staff believes that the reasons for the large difference between an expected Cs-137:I-129 ratio of 75,000 and an observed ratio of 170 should be thoroughly understood by DOE. DOE believed that the data suggest no further sampling was needed for I-129, however, the NRC staff did not agree with this assessment based on the current information. The staff believes that further understanding of the differences may be derived from studying the waste that was being added to Cell E (which perhaps had a substantially different ratio of Cs-137:I-129 than that of the expected long-term average concentration of salt waste), or in terms of natural processes that may have governed the ratio of Cs-137:I-129 in the soil.

NRC staff also asked whether DOE had considered sampling under footers at the base of the Vault south wall, in order to test whether the floor of the vault may also have active weep sites. DOE explained that the causes of the discontinuities in construction that resulted in active weep sites in the vault walls are not anticipated in the floor of the vault, and believes that no sampling below the footers is necessary. Downgradient groundwater monitoring will continue to be relied upon to ascertain whether contamination from active weep sites, or any other potential sources, is migrating away from Vault 4. NRC staff commented that valuable lessons can be learned by the observed distribution of contamination in the subsurface, and that those lessons should be applied to revisions of the performance assessment.

<u>DOE Follow-up Actions</u>

6. DOE should continue to investigate the source of iodine-129 detected in soil samples.

Sorption (Kd), Desorption, and Reduction Capacity Measurements

Report 6 provides the results of research on sorption, desorption, and reduction capacity measurements that were performed on laboratory-prepared samples of saltstone grout and vault concrete. DOE explained that data from this report will be used in its update of the salt waste performance assessment. Of particular interest to NRC staff, are the results for sorption (Kd) and desorption of technetium-99 in this report. The Kd values obtained for technetium in these experiments were significantly less than the values assumed in the performance assessment, indicating that it would be significantly more mobile than assumed in the performance assessment. Additionally, technetium was apparently not reduced in the experiments described in this report. NRC staff recognizes that the purpose of these experiments was to determine the transport of technetium through the saltstone vault rather than the ability of saltstone to immobilize technetium during curing. However, because the technetium did not become reduced in the presence of saltstone, staff requested additional information about the basis for DOE's confidence that technetium in salt waste would be reduced as saltstone grout cures.

During the observation, DOE explained that while there is currently no experimental basis that specifically supports DOE's assumption that technetium-99 in salt waste will be reduced, and thereby retained, in the current saltstone grout formulation, DOE plans to perform additional experiments that will be designed to support such an assumption later this year. Given the risk significance of this assumption in DOE's performance assessment (DOE, 2005), this is a new open issue under Section 3.2.4 of the NRC monitoring plan (NRC, 2007).

Open Issue 2009-1

At the SRS Saltstone Facility, DOE should demonstrate that (1) technetium-99 in salt waste is converted to its reduced chemical form in saltstone grout during the curing of saltstone grout, and is thereby strongly retained in saltstone grout, and (2) the sorption of dissolved technetium-99 onto saltstone grout and vault concrete is consistent with K_d values for technetium-99 that were assumed in the performance assessment.

DOE Follow-up Actions

7. Explain what measures were taken to ensure that experiments with technetium were not affected by experimental losses, such as technetium holdup in labware, resulting in underestimates of technetium concentration.

8. Clarify the pH of the calcite solution used in these experiments (page 9 and 16 state the pH = 10; page 7 states that solution pH = 8.3).

9. Clarify the selenium Kd value reported in Table 5, which is different than the value reported previously in the report.

Hydraulic and Physical Properties of Saltstone Grouts and Vault Concretes

Report 7 provides the results of research on physical properties of laboratory-prepared samples of saltstone grout and vault concrete. NRC staff noted that material porosity measurements were as expected, but that the saturated hydraulic conductivity measurements for both saltstone grout and vault concrete and the porosity of saltstone were much higher than expected. Higher saturated hydraulic conductivity would be expected to lead to higher water flow rates, and higher associated degradation of saltstone grout and vault concrete than calculated in the salt waste performance assessment. NRC staff expressed the concern that the wasteform properties are one of the key components to mitigating risk from saltstone, and that inferior hydraulic properties are likely correlated with inferior diffusivity, which can impact long-term durability. NRC staff asked how the new measurement information will be incorporated into the performance assessment. DOE stated that it compares the information to sensitivity cases, and the new information would be reflected in the new performance assessment. The annual regulatory report identifies new information and identifies when the performance assessment needs to be updated. NRC staff indicated that the new information on hydraulic and physical properties could impact other activities, such as degradation assessments. DOE indicated that an integration team helps to ensure that new information is reflected in other products. NRC staff inquired about the status of implementation of the Saltstone Product Quality Plan. DOE indicated they would provide a status of implementation and may update analysis after it is fully implemented.

NRC staff discussed the measurement of moisture characteristics curves. The report provided recent measurements for saltstone and vault concrete that were substantially different than similar measurement completed by the Idaho National Laboratory (INL). NRC staff discussed how the data were going to be used and interpreted. DOE indicated that they had planned to use the data from INL and they had not performed an evaluation of the impact of different moisture characteristic curves. NRC staff indicated that the moisture characteristics curves can have a large impact on projected waste release rates, and if there is significant uncertainty or variability in the values that the uncertainty and variability should be evaluated in the performance assessment.

DOE Follow-up Actions

10. Clarify whether bleedwater was leaking from sealed containers during the hydraulic properties study, when the report indicated the samples were sealed.

11. Clarify the impact of changing pore solution concentration on measured hydraulic properties on page 8 of Report 7.

12. Explain how uncertainty will be addressed for moisture characteristic curves that are fit to data reported on page 18 of Report 7.

13. Justify the use of logarithmic averages for recommended hydraulic property values on p. 19.

NRC also requested additional information about the results of physical or chemical tests being performed on core samples that were taken from three locations along the western wall of Cell E of Vault 4 in September 2008. Each core was approximately 3 to 4 inches in diameter and 6 inches deep. DOE explained that it is planning laboratory studies that may begin during the third quarter Fiscal Year 2009, in which it will test porosity, saturated hydraulic conductivity, and distribution coefficients for radionuclides. NRC staff will follow up on DOE's progress in preparing experiments for these core samples in future monitoring activities. A representative from the South Carolina Department of Health and Environmental Control suggested that it would be very useful to perform leaching studies of the saltstone core samples, and NRC staff agreed.

Video Survey of Vault 4, Cell G

Observation participants watched a video survey of Cell G in Vault 4 (Report 14). The video showed fractures on the surface of the saltstone. Of particular interest was a large aperture crack emanating from the north corner of Cell G. This crack propagates out from the corner at approximately a 45 degree angle and appears to extend entirely across the cell. Staff also noted, as stated in Report 14, that there is no obvious separation between the vault wall and saltstone associated with shrinkage of the saltstone grout. The surface of the saltstone appeared to be rough and contained areas of darker color. DOE explained that the roughness was attributed to dripping condensation during curing and the dark spots were attributed to corrosion of steel in the vault roof that dripped onto the surface of the saltstone. Staining along one of the cracks likely indicated that water contained corrosion products collected and flowed into the fracture. NRC staff noted that the fractures do not appear to be extensive, but that conclusion was hindered by lack of scale and a limited survey area. DOE plans to do more surveys in the future.

Evaluation of Sulfate Attack on Saltstone Vault Concrete and Saltstone

Observation participants discussed NRC staff questions on Reports 8 and 9.

DOE Follow-up Actions

14. Provide up-to-date copy of the PA maintenance plan

15. Evaluate the sensitivity of grid spacing to predicted front propagation in the sulfate attack evaluation.

16. Explain how spatial representation in the numerical experiments of sulfate attack will be translated into a PA model, since the geometries of the real system will be much more complex (e.g., a random collection of different size blocks determined by crack distributions) than those considered in the numerical experiments.

17. Explain how cracks are incorporated into the sulfate attack representation in the PA model, since cracks could significantly impact the degradation assessment (page 15). Explain assumption I that the transport rate through damaged concrete of sulfate ions is not different from undamaged concrete (page 21).

18. Clarify the conceptual model for sulfate attack. For example, does sulfate attack proceed along a front, or is it a generalized mechanism

19. Clarify the conceptual model represented by case 2 (page 6). If the concentration was diluted by diffusion, then what is the fate of diffused species? If species are diffusing through the vault wall, then why isn't the vault wall degraded.

20. Explain why it is appropriate to neglect minor species (page A2-14).

21. Justify the use of Berner's approach for these materials and solutions (page A2-15).

2.3.3 Conclusions and Followup Actions

There are no recommendations resulting from staff observations at this time.

There is one new open issue regarding whether: (1) technetium-99 in salt waste is converted to its reduced chemical form in saltstone grout during the curing of saltstone grout, and is thereby strongly retained in saltstone grout, and (2) the sorption of dissolved technetium-99 onto saltstone grout and vault concrete is consistent with K_d values for technetium-99 that were assumed in the performance assessment.

DOE follow up actions are listed in section 2.3.2 above.

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September 30, 2009

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SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION JUNE 3, 2009, ONSITE OBSERVATION REPORT FOR THE SAVANNAH RIVER SITE SALTSTONE FACILITY

Dear Mr. Gutmann:

The enclosed report describes the U.S. Nuclear Regulatory Commission's (NRC's) onsite observation activities on June 3, 2009, at the Savannah River Site (SRS) Saltstone Facility. This onsite observation was conducted in accordance with Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (Section 3116), which requires NRC to monitor disposal actions taken by U.S. Department of Energy (DOE) for the purpose of assessing compliance with the performance objectives set out in 10 CFR Part 61, Subpart C. The activities conducted during the site visit were consistent with those described in the NRC's monitoring plan for salt waste disposal at SRS (dated May 3, 2007) and NRC's staff guidance for activities related to waste determinations (NUREG-1854, dated August 2007).

Though all performance objectives are considered during every monitoring event, this onsite observation at SRS was primarily focused on assessing compliance with the performance objective in 10 CFR 61.41, Protection of the general population from releases of radioactivity, by observing DOE's ongoing construction of disposal cells at the Saltstone Disposal Facility (SDF).

NRC continues to conclude that there is reasonable assurance that the applicable criteria of Section 3116 can be met if key assumptions made in DOE's waste determination analyses prove to be correct. In accordance with the requirements of Section 3116 and consistent with NRC's monitoring plan for the salt waste disposal facility, NRC will continue to monitor DOE's disposal actions at SRS. The monitoring activities are expected to be an iterative process. Several onsite observation visits and technical reviews may be necessary in order to obtain the information needed to close all of the current open issues, as well as issues that may be opened in the future.

If you have any questions or need additional information regarding this report, please contact Nishka Devaser of my staff at (301) 415-5196.

Sincerely,

/RA/

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NRC Observation Report

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U.S. NUCLEAR REGULATORY COMMISSION JUNE 3, 2009, ONSITE OBSERVATION REPORT FOR THE SAVANNAH RIVER SITE SALTSTONE FACILITY

EXECUTIVE SUMMARY

U.S. Nuclear Regulatory Commission (NRC) staff conducted its fifth onsite observation visit of the Saltstone Facility at the Savannah River Site (SRS) on June 3, 2009. This visit was intended to focus on one of the four performance objectives — 10 CFR 61.41, "*Protection of the general population from releases of radioactivity*," — by obtaining information on construction of disposal Cells 2A and 2B of the U.S. Department of Energy (DOE) saltstone disposal facility. This report provides a description of NRC onsite observation activities and identifies NRC observations from the visit. Based on the results of the visit, the NRC continues to have reasonable assurance that the performance objectives of 10 CFR 61 can be met.

There are no new open issues resulting from this observation, however, at the time of the observation, the revised performance assessment for the new vault design was not yet available for NRC staff review. As a result, staff was unable to fully assess risk significance of construction activities and materials used in construction. A summary of the staff's observations and conclusions is provided below:

Disposal Cell Construction

- The staff observed ongoing construction at Saltstone Disposal Facility Cells 2A and 2B. At the time of the staff's visit, all vertical wall panels were installed for both cells. Closure strips had been installed for disposal cell 2B and preparation was complete for the introduction of structural concrete between panel interstices.

- The DOE has one follow-up action from this activity relating to NRC staff's request for vendor-supplied historical documentation of the performance of various construction materials as well as documentation of materials testing performed by the disposal cell vendor. NRC staff also made a recommendation that DOE either verify that concrete quality assurance requirements in a required national code and standard is being met, or determine the effects of any deviations on performance of the concrete.

1.0 BACKGROUND

Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (Section 3116) authorizes the DOE, in consultation with the NRC, to determine that certain radioactive waste related to the reprocessing of spent nuclear fuel is not high-level waste, provided certain criteria are met. Section 3116 also requires NRC to monitor DOE disposal actions to assess compliance with the performance objectives in 10 CFR Part 61, Subpart C.

On March 31, 2005, DOE submitted a "Draft Section 3116 Determination, Salt Waste Disposal Savannah River Site" to demonstrate compliance with the Section 3116 criteria, including demonstration of compliance with the performance objectives in 10 CFR Part 61, Subpart C (DOE, 2005). In its consultation role, the NRC staff reviewed the draft waste determination and concluded that there was reasonable assurance that the applicable criteria of Section 3116 could be met, provided certain assumptions made in DOE's analyses are verified via monitoring. NRC documented the results of its review in a technical evaluation report (TER) issued in

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December 2005 (NRC, 2005). DOE issued a final waste determination in January 2006 taking into consideration the assumptions, conclusions, and recommendations documented in NRC's TER (DOE, 2006).

To carry out its monitoring responsibility under Section 3116, NRC plans to perform three types of activities: (i) technical reviews, (ii) onsite observations, and (iii) data reviews. These activities will focus on key assumptions — called "factors" — identified in the NRC monitoring plan for saltwaste disposal at SRS (NRC, 2007). Technical reviews generally will focus on obtaining additional model support for assumptions DOE made in its performance assessment (PA) that are considered important to DOE's compliance demonstration. Onsite observations generally will be performed to (i) observe the collection of data (e.g., observation of waste sampling used to generate radionuclide inventory data) and review the data to assess consistency with assumptions made in the waste determination, or (ii) observe key disposal (or closure) activities related to technical review areas (e.g., slag and other material storage, grout formulation and preparation, and grout placements). Data reviews will supplement technical reviews by focusing on monitoring data that may also indicate future system performance or by reviewing records or reports that can be used to directly assess compliance with performance objectives.

On June 3, 2009, the NRC staff onsite observation visit at SRS focused primarily on the performance objective in 10 CFR 61.41, *Protection of the general population from releases of radioactivity* by observing DOE's ongoing construction of disposal cells at the Saltstone Disposal Facility (SDF). Future visits will assess the performance objective in 10 CFR 61.42, *Protection of individuals against inadvertent intrusion*, and also continue to assess DOE compliance with the other performance objectives.

Saltstone Facility Operational Status at the time of the Observation

At the beginning of the visit, DOE and DOE contractor staff provided a brief overview of operations at the Saltstone Facility and the status of disposal cell 2 construction since the last onsite observation (NRC, 2009). The DOE contractor then led NRC staff accompanied by the South Carolina Department of Health and Environmental Control (SCDHEC) on a tour of the disposal cell 2 construction site. NRC staff observed construction activities associated with concrete placement in some of the 32 closure strips of Tank 2B.

At the time of the observation, DOE was starting a transition to a new liquid waste contractor, Savannah River Remediation, LLC (SRR), which will succeed the Washington Savannah River Company (WSRC) on July 1, 2009 (DOE, 2009).

2.0 NRC ONSITE OBSERVATION ACTIVITIES

2.1 Disposal Cell Construction

NRC staff monitors ongoing construction of disposal cells, as described in section 3.2.3, "Vault Construction," of the staff's monitoring plan (NRC, 2007).

2.1.1 Observation Scope

The observation of DOE vault construction is related to Factor 1 – "Oxidation of Saltstone," Factor 2 – "Hydraulic Isolation of Saltstone," and Factor 3 – "Model Support," which were identified in the NRC monitoring plan for the SRS SDF (NRC, 2007). The monitoring plan also states the importance of understanding potential mechanisms that could result in loss of vault integrity. The disposal cell system is comprised of a number of different engineering materials designed to properly interact to contribute to leak proof performance. These include reinforced concrete, steel, epoxy, caulk, HDPE liners, and rubber. Each of these materials, individually, has unique physical and chemical characteristics that will vary with time and changes in environment. Staff would like to gain a better understanding of how these materials will behave during the performance period of these cells.

The general purpose of NRC staff observations of ongoing construction of Saltstone Facility disposal cells 2A and 2B is to identify noticeable deviations from the vault design, focusing on changes that could affect potential pathways for water to intrude into the vaults, such as penetrations or joints. In addition to material effects, NRC staff paid particular attention to those processes contributing to the assembly and installation the vault wall panels.

2.1.2 Observation Results

The staff observed ongoing construction at Saltstone Facility disposal cells 2A and 2B. At the time of the staff's visit, the cell floors and all wall panels had been fully installed for disposal cells 2A and 2B, most of the wall panel joints had been poured for disposal cell 2B. NRC staff also observed construction activities associated with concrete placement in some of the 32 closure strips of disposal cell 2B.

2.1.2.1 Concrete Batch Accounting

Staff reviewed a concrete batch ticket package that contained two documents. The documents were associated with the batch that was delivered and placed in the closure gaps. One document contained information regarding initial batch time, and the other document indicated the time that the truck left the batch plant. This batch was tested for slump, air content, temperature, and concrete cylinders were made for compressive testing. QORE Property Sciences is the subcontractor responsible for independent materials testing, which includes but is not limited to performing the on-site concrete receipt testing and making the concrete test cylinders to be used for compressive strength breaks. The QORE representative on-site performed the concrete receipt testing, made the concrete test cylinders to be used for compressive strength breaks, and recorded and reviewed the results of the tests. The batch ticket indicated that the concrete was initially batched (water added) at 11:40 a.m., the truck left the batch plant at 12:15 p.m. The QORE representative stated that the truck was finished pouring at 1:47 p.m., which is in excess of 2 hours. ASTM C94 (ASTM, 2009) states the following:

> *'Discharge of the concrete shall be completed within 1½ hours or before the drum has revolved 300 revolutions, whichever comes first, after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates. These limitations are permitted to be waived by the purchaser if the concrete is of such slump after the 1½-h time or 300-revolution limit has been reached that it can be placed, without the addition of water, to the batch.'*

Upon review of ASTM C94 (ASTM, 2009), staff believes that not meeting, by a small margin, the discharge time limit specified in the standard may not have a significant impact on long-term concrete strength and stability of the disposal cells, especially if the concrete had been determined to be "of such slump. . . that it can be placed without the addition of water.". The staff have not identified any follow-up actions, open issues or recommendations associated with this observation.

2.1.2.2 Closure Strip Deviations

ACI 117-06, Section 2.3.1 (ACI, 2006) provides requirements for placement of embedded items and states *'Clear distance to nearest reinforcement shall be the greater of the bar diameter or 1 in.'* The commentary section R2.3 provides further clarification on this requirement with diagrams showing the clear distance should be from the embedment and the stud (Figure 1 shows the requirements designated by ACI 117-06 and Figure 2 shows a photograph of the closure strips used in disposal cell 2A [taken onsite during June 3 observation]).

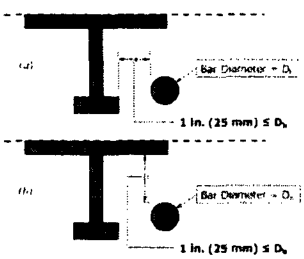

Figure 1: ACI 117-06 Requirements


Figure 2: June 3, 2009 Photograph of Closure Strip

One of the intents of this requirement is to ensure proper concrete consolidation and bonding to all surfaces of the embedment and rebar and to prevent localized voiding issues. The steel closure strips were constructed with studs embedded in the concrete and rebar was placed less than 1" from these studs and in several instances actually in contact with the studs. Voiding issues of this sort could lead to preferential pathways within the disposal cell and could produce unforeseen weaknesses during the performance period. Given the potential for localized voiding created by this deviation, the staff recommends that DOE either confirm the absence of such voids or consider the potential for such voids in evaluating the performance of the cells.

2.1.2.3 Materials Performance

Many engineering materials are being used in construction of the disposal cells. These materials have properties potentially affecting long-term performance of the disposal cells. NRC staff requested information from the vendor, which has decades of experience with the performance of these materials, in order to evaluate whether past experience with tanks of similar design might be useful in predicting long-term performance of the disposal cells.

2.1.3 Conclusions and Follow-up Actions

No open issues were identified during the observation of disposal cell construction. However, staff observed deviations of required concrete codes and standards. NRC staff would like to discuss these deviations in future meetings. NRC staff have identified one follow-up action and one recommendation at the close of this observation.

DOE Follow-up Action

Provide vendor-supplied historical documentation of performance of various materials used in construction as well as documentation of materials testing performed by the disposal cell vendor.

DOE Recommendation

DOE should either confirm the absence of voids caused by deviation from ACI 117-06, or consider the potential for such voids in evaluating the performance of the cells

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October 1, 2009

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SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION AUGUST 10-14, 2009 ONSITE OBSERVATION REPORT FOR THE SAVANNAH RIVER SITE SALTSTONE FACILITY

Dear Mr. Gutmann:

The enclosed report describes the U.S. Nuclear Regulatory Commission's (NRC's) onsite observation activities on August 10-14, 2009, at the Savannah River Site (SRS) Saltstone Facility. This onsite observation was conducted in accordance with Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (Sect. 3116), which requires NRC to monitor disposal actions taken by the U.S. Department of Energy (DOE) for the purpose of assessing compliance with the performance objectives set out in 10 CFR Part 61, Subpart C. The activities conducted during the site visit were consistent with those described in the NRC's monitoring plan for salt waste disposal at SRS (dated May 3, 2007) and NRC's staff guidance for activities related to waste determinations (NUREG-1854, dated August, 2007).

This onsite observation at SRS was focused on assessing compliance with all four of the performance objectives in 10 CFR Part 61, by observing DOE's review process of the performance assessment for the Saltstone Disposal Facility at the SRS.

NRC continues to conclude that there is reasonable assurance that the applicable criteria of Sect. 3116 can be met if key assumptions made in DOE's waste determination analyses prove to be correct. In accordance with the requirements of Sect. 3116 and consistent with NRC's monitoring plan for the Saltstone Disposal Facility, NRC will continue to monitor DOE's disposal actions at SRS. The monitoring activities are expected to be an iterative process. Several onsite observation visits and technical reviews may be necessary in order to obtain the information needed to close all of the current open issues, as well as issues that may be opened in the future.

If you have any questions or need additional information regarding this report, please contact Nishka Devaser of my staff at (301) 415-5196.

Sincerely,

/RA/

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NRC Observation Report

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U.S. NUCLEAR REGULATORY COMMISSION AUGUST 10 - 14, 2009 ONSITE OBSERVATION REPORT FOR THE SAVANNAH RIVER SITE SALTSTONE FACILITY

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) staff conducted its sixth onsite observation visit to the Saltstone Facility at the Savannah River Site (SRS) on August 10-14, 2009. The intention of this visit was to focus on all four performance objectives by observing the onsite portion of the Low-Level Waste Disposal Facility Federal Review Group (LFRG). The LFRG performs an extensive review of each performance assessment (PA) prepared by a U.S. Department of Energy (DOE) facility and as such is a critical step in the process of preparing the PA. This report provides a description of NRC onsite observation activities and identifies NRC observations from the visit. Based on the results of the visit, the NRC continues to have reasonable assurance that the performance objectives of 10 CFR 61 can be met in the areas reviewed.

There are no new open issues resulting from this observation. A summary of the staff's observations and conclusions is provided below:

Performance Assessment Process Review

- The staff observed the LFRG review of the revised performance assessment for the Saltstone Disposal Facility. The review team consisted of relevant subject matter experts employed by DOE, either as federal employees at DOE (Headquarters or another DOE facility) or as technical experts, contractors, or academics associated with one of these locations. The team reviewed the draft PA and associated documents for 30 days prior to the start of the onsite review, which consisted of four days of additional review, in which team members conducted interviews with involved subject matter experts and began preparing their respective parts of the LFRG final report.
- The process observed by the staff seemed thorough and comprehensive. The LFRG vetting process provided the NRC staff assurance that public health and safety were appropriately considered during the review. The NRC staff, however, will have a better understanding of the effectiveness of the LFRG review process once the revised PA has been released and provided to NRC.

1.0 BACKGROUND

Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (Section 3116) authorizes the DOE, in consultation with the NRC, to determine that certain radioactive waste related to the reprocessing of spent nuclear fuel is not high-level waste, provided certain criteria are met. Section 3116 also requires NRC to monitor DOE disposal actions to assess compliance with the performance objectives in 10 CFR Part 61, Subpart C.

On March 31, 2005, DOE submitted a "Draft Section 3116 Determination, Salt Waste Disposal Savannah River Site" to demonstrate compliance with the Sect. 3116 criteria including demonstration of compliance with the performance objectives in 10 CFR Part 61, Subpart C (DOE, 2005a). In its consultation role, the NRC staff reviewed the draft waste determination and concluded that there was reasonable assurance that the applicable criteria of Sect. 3116 could

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be met, provided certain assumptions made in DOE's analyses are verified via monitoring. NRC documented the results of its review in a technical evaluation report issued in December 2005 (NRC, 2005). DOE issued a final waste determination in January 2006 taking into consideration the assumptions, conclusions, and recommendations documented in NRC's Technical Evaluation Report (DOE, 2006).

To carry out its monitoring responsibility under Sect. 3116, NRC plans to perform three types of activities: (i) technical reviews, (ii) onsite observations, and (iii) data reviews. These activities will focus on key assumptions—called "factors"—identified in the NRC monitoring plan for saltwaste disposal at SRS (NRC, 2007). Technical reviews generally will focus on obtaining additional model support for assumptions DOE made in its performance assessment that are considered important to DOE's compliance demonstration. Onsite observations generally will be performed to (i) observe the collection of data (e.g., observation of waste sampling used to generate radionuclide inventory data) and review the data to assess consistency with assumptions made in the waste determination, or (ii) observe key disposal (or closure) activities related to technical review areas (e.g., slag and other material storage, grout formulation and preparation, and grout placements). Data reviews will supplement technical reviews by focusing on monitoring data that may also indicate future system performance or by reviewing records or reports that can be used to directly assess compliance with performance objectives.

1.1 LFRG PA Review Process

During the week of August 10-14, 2009, the NRC staff onsite observation visit at SRS focused on all four of the performance objectives. The staff attended the Low-Level Waste Disposal Facility Federal Review Group (LFRG) Review Team site visit for the review of the *Performance Assessment (PA) for the Saltstone Disposal Facility at the Savannah River Site (LWP-RIP-2009-00011)*. The LFRG consists of Federal employees from DOE Headquarters and DOE field organizations and typically includes technical experts subcontracted from other DOE sites. The group performs a review of all DOE LLW disposal facilities PAs and composite analyses and supports the process of granting Disposal Authorization Statements. DOE Office of Environmental Management tasks the LFRG with providing the information necessary to determine whether the design, construction, operation, maintenance, and closure of DOE's LLW disposal facilities sufficiently protect public health and safety.

2.0 NRC ONSITE OBSERVATION ACTIVITIES

2.1 Performance Assessment Process Review

NRC staff monitors ongoing revision of the PA for the Saltstone Disposal Facility at the SRS, as described in Section 3.1.9, "Performance Assessment Process Review," of the staff's monitoring plan (NRC, 2007).

2.1.1 Observation Scope

The observation of the LFRG PA review is related to the Technical Review Factors identified in the NRC monitoring plan for the SRS Saltstone Disposal Facility (NRC, 2007). The monitoring plan states the importance of NRC staff evaluating revisions and updates made to the PA to determine if the PA continues to provide reasonable assurance that the long-term performance of the wasteform and its surrounding system will maintain public health and safety.

The general purpose of NRC staff review of the Saltstone Disposal Facility PA revision is to continue to verify compliance with the performance objectives listed in 10 CFR Part 61, Subpart C.

2.1.2 Observation Results

During this review, the LFRG review team evaluated the PA and supporting documentation to confirm that the PA is complete, thorough, and technically supported, and the conclusions are valid and acceptable. The review team members included technical experts from other DOE sites with various areas of relevant technical expertise. Team members were given 30 days to review the PA and associated documents prior to the onsite portion of the review.

At the beginning of the week, prior to start of the review, SRS staff gave the LFRG review team a tour of the Saltstone Disposal Facility, including the existing vaults as well as the new vaults currently under construction. Site staff also gave an overview presentation describing their performance assessment methodology and results. Members of the review team also had an opportunity to discuss the PA with the subject matter experts who were involved in the development of the PA or research that supported the PA. These technical experts provided the review team with additional information on the methodology used in the performance assessment and the technical basis for assumptions made in the PA. The technical areas discussed included topics such as the methodology used in the PORFLOW and GoldSim computer modeling codes, the possible degradation mechanisms of the saltstone, the potential for oxidation of Tc in saltstone, the development of the inventory included in the performance assessment, and the uncertainty and sensitivity analyses performed.

The review team used the information presented in the PA and supporting documents and the information gathered in discussions with site staff to evaluate if the PA met the criteria identified in the respective LFRG Review Plan. In cases where the criteria were not met, the review team identified causality. Issues identified were then categorized into key issues and secondary issues. Key issues require resolution as a condition of acceptance of the PA. Secondary issues are important, but not critical to PA acceptance, and describe areas for improvement that should be tracked and resolved through the site maintenance plan (DOE, 2005b).

The review team discussed the potential issues identified and reached a consensus on the lists of key and secondary issues. The LFRG Review Team developed a report documenting the team's consensus opinion. Individual review team members were also provided an opportunity to submit a separate description of their review that provides additional details about their evaluation of the performance assessment.

At the conclusion of the review, the LFRG Review Team briefed the SRS site staff and management on conclusions reached during the review. The LFRG Review Team is also providing a copy of the draft Review Team report to the SRS staff for a review of factual accuracy. Once finalized, the report will be submitted to the LFRG.

NRC staff appreciated the invitation and the opportunity to observe the process and was impressed at the rigorousness of the review. The team was both technically diverse and consisted of members highly regarded in their respective fields. Points of interest, concerns, and conclusions identified by the team were typically consistent with those identified in NRCs review(s) of similar subject matter. The NRC staff must acknowledge, however, that a comprehensive assessment of the process must include analysis of process output as well as input. The LFRG Final Report and the PA will be the outputs to this process, with greater emphasis put on the PA.

2.1.3 Conclusions and Follow-up Actions

No NRC issues were identified during the observation of LFRG review. The NRC staff still has reasonable assurance that the performance objectives are currently being met. However, the staff recognizes that the evaluation of the effectiveness of the LFRG process review can only be fully complete at the release of the revised PA.

3.0 PARTICIPANTS

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U.S. Department of Energy (DOE). DOE-WD-2005-001, "Basis for Section 3116 Determination Salt Waste Disposal at the Savannah River Site." Washington, DC: DOE. March 2005a.

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———. DOE-WD-2005-001, "Basis for Section 3116 Determination Salt Waste Disposal at the Savannah River Site." Washington, DC: DOE. January 2006.

U.S. Nuclear Regulatory Commission (NRC). "Technical Evaluation Report for Draft Waste Determination for Salt Waste Disposal." Letter from L. Camper to C. Anderson, DOE. December 28, 2005. (Agencywide Documents Access and Management System (ADAMS) Accession No. ML053010225)

———. "U.S. Nuclear Regulatory Commission Plan for Monitoring the U.S. Department of Energy Salt Waste Disposal at the Savannah River Site in Accordance with the National Defense Authorization Act for Fiscal Year 2005." Washington, DC: NRC. May 3, 2007. (ADAMS Accession No. ML070730363)

APPENDIX D: 2009 TECHNICAL REVIEWS

U.S. Nuclear Regulatory Commission Technical Review Summary Reports for Calendar Year 2009

August 25, 2009

MEMORANDUM TO: Gregory Suber, Chief
Low-Level Waste Branch
Environmental Protection and
Performance Assessment Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

THRU: Christepher McKenney, Chief **/RA/ by D. Esh for**
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FROM: David Esh, Sr. Systems Performance Analyst **/RA/**
Performance Assessment Branch
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SUBJECT: TECHNICAL REVIEW: "HYDRAULIC AND PHYSICAL PROPERTIES OF SALTSTONE GROUTS AND VAULT CONCRETES"

On January 9, 2009, the U.S. Department of Energy, Savannah River Operations Office, provided the subject report for review by NRC staff pursuant to Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (ML090150297). The subject report is available on NRC's Agencywide Documents Access and Management System (ADAMS) at accession number ML090150298. This report was reviewed in accordance with

CONTACT: David Esh, FSME/DWMEP
301-415-6705

Technical Review Summary: *TECHNICAL REVIEW: "HYDRAULIC AND PHYSICAL PROPERTIES OF SALTSTONE GROUTS AND VAULT CONCRETES"*

Review Completed: March 20, 2009

Reviewer(s): D. Esh

Document(s): Dixon, K., J Harbour, M. Phifer, *Hydraulic and Physical Properties of Saltstone Grouts and Vault Concretes*, SRNS-STI-2008-00421, Revision 0, Savannah River National Laboratory, WSRC. November 2008, ADAMS accession no. ML090150298

Evaluation

The primary focus of the report is to provide a summary of work performed to estimate the hydraulic and physical properties of three types of saltstone and two vault concretes. Wet properties measured on the saltstone formulations included yield stress, plastic viscosity, wet unit weight, bleed water volume, gel time, set time, and heat of hydration. Hydraulic and physical properties measured on cured saltstone and concrete samples included saturated hydraulic conductivity, moisture retention, compressive strength, porosity, particle density, and dry bulk density. Water retention data are presented for each material along with van Genuchten transport parameters determined with the RETC code.

The report provides a summary of previous initial testing of saltstone grout that provided the basis for hydraulic conductivity values used in the performance assessment and subsequent special analysis. The report provides an adequate summary of the sample preparation and analysis methods for the various measurements. In appendicies, the report provides strength reports and materials characterization test reports provided by the contractors that performed the measurements.

Note: All citations to previous work noted below are those cited in SRNS-STI-2008-00421.

Yu et al. (1993) measured a saturated hydraulic conductivity of 5.19E-12 cm/s, whereas Langton (1986) reported the results of previous testing that ranged from 3E-9 to <1E-11 cm/s. More recent measurements by Harbour et al. (2007a) estimated the hydraulic conductivity of saltstone as ranging between 1.4 to 3.4E-9 cm/s. Dixon and Phifer (2007) estimated the hydraulic conductivity of saltstone relative to the saltstone pore fluid of 5.3E-9 cm/s. The more recent measurements by Harbour, Dixon and Phifer did not corroborate the previous measurements by Yu and Langton. The saltstone performance assessment (2005) used an initial saturated hydraulic conductivity for the base case of 1E-11 cm/s for saltstone and 1E-12 cm/s for the vault concrete. In addition, the porosity measured in the most recent experiments described in this report was on the order of 0.6 to 0.7, much higher than used in the previous performance assessment of 0.42.

The differences in the results between the older and more recent measurements highlight a challenge in relying on limited measurements for parameters that are difficult to measure. Higher than expected hydraulic conductivity for the saltstone and vault concrete and porosity for the saltstone would be expected to lead to higher water flow rates, faster degradation, and higher release rates of radionuclides than previously anticipated (DOE, 2005). Anticipated degradation mechanisms that may proceed more quickly would include but not be limited to

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sulfate attack, reinforcement corrosion (when applicable), and leaching of calcium hydroxide. In addition, it is likely that higher hydraulic conductivity and porosity would correlate with higher than anticipated diffusivity which would impact the rate at which deleterious species can be transported to the grout or concrete and the rate at which radionuclides would be transported from the grout. DOE is in the process of revising the previous performance assessment. NRC staff plan to evaluate the revised performance assessment to ensure that the values for hydraulic conductivity, porosity, and diffusivity used in the performance assessment reflect the recent measurements and additional uncertainties. Additional uncertainties that could impact the physical property data and that may not be reflected in the more recent measurements were discussed with DOE during the March 2008 monitoring visit (ML081290367). DOE stated that, as a result of that monitoring visit, they were initiating a saltstone product quality assurance strategy to address the additional uncertainties. NRC staff will evaluate information that is generated as it becomes available. In addition to impacting the performance assessment calculation, changes to key variables may impact the assessment of the impact of other processes or uncertainties. For example, the extent of sulfate attack is strongly influenced by the diffusivity of the material. The research process to address uncertainties in performance of the saltstone disposal facility should properly integrate the results of individual studies, many of which may be completed in parallel. NRC staff plan to evaluate future reports and information generated by DOE to assess whether the reports are consistent and appropriately integrated.

This report summarizes and recommends logarithmic averages of hydraulic conductivity for use in future performance assessments, but does not explain why the logarithmic average is appropriate given the limited number of measurements and understanding about the underlying parameter distribution. In this case, the logarithmic average is lower than the arithmetic mean, and should only be used if it can be shown that the data are logarithmically distributed.

Hydraulic conductivity measurements were performed on test cylinders that were 2.8 x 6.0 inches that were filled, capped, and sealed. Page 4 of the report states that bleed liquid leaked from the hydraulic test cylinders during the cure period. It is not clear what is meant by the text, if the cylinders were sealed. NRC asked for additional information at the March 2009 monitoring visit. Adequate seals of the samples can be important in these types of measurements because leakage between the sample and sample holder can influence the measurements and result in inaccurate data for the fundamental hydraulic properties of the material.

The hydraulic conductivity measurements discussed in the report were conducted with a simulated groundwater permeant for vault concrete and a permeant of similar composition as salt waste for saltstone grout. Due to the small volume of permeant used in these tests relative to the volume of simulant used to prepare the samples (i.e., a stimulant to permeant volume ratio of 1:150), the measured hydraulic conductivity values are considered to be representative of the simulant used to prepare the test materials. The report states that geochemical modeling was performed to assess the potential for chemical reactions between the simulants and grout that could impact the property testing. As the material ages, it would be expected that the grout would be less reactive and therefore the permeants contacting the material would be less concentrated because the permeants would contain less salts and other soluble components from reaction with the grout itself. In order for the data generated in the report to apply for degraded conditions, it would be necessary to derive intrinsic permeabilities that are specific to anticipated future groundwater compositions. However, the staff believes that this source of uncertainty may not be significant relative to the other sources of uncertainty.

The report summarizes measurements of moisture characteristic curves for saltstone and vault concrete and also provides data from similar measurements completed by the Idaho National Laboratory (INL). Page 18 of the report discusses a fitting procedure to develop the parameterization of the moisture characteristic curves. The fitting procedure appears to be loosely constrained, which could result in non-unique solutions. The moisture characteristic curve measurements are difficult to perform and can be subject to considerable uncertainty. For example, page 32 of the report provides the characteristic curves for MCU saltstone samples as determined by INL. Figure 15 on page 31 of the report provides the characteristic curve measured for ARP/MCU saltstone in the current study. The moisture characteristic curves are markedly different. In simulations of facility performance, differences in the assigned moisture characteristic curves of dissimilar materials can sometimes have a profound effect on estimated release rates due to the strong non-linear relationship between saturation and relative permeability. NRC staff will evaluate the revised performance assessment to see if the results of the performance assessment are sensitive to the assigned moisture characteristic curves and how uncertainty in the moisture characteristic curves was evaluated in the revised performance assessment.

Teleconferences or Meetings

The subject report was discussed with representatives of the Department of Energy and its contractors on March 25-26, 2009 at an onsite observation at the Savannah River Site (SRS). A summary of the discussion is provided in the onsite observation report (ADAMS accession no. ML091320439). The follow-up actions as a result of the discussion are:

1) Clarify whether bleedwater was leaking from sealed containers during the hydraulic properties study, when the report indicated the samples were sealed;
2) Clarify the impact of changing pore solution concentration on measured hydraulic properties on p. 8 of the report;
3) Explain how uncertainty will be addressed for moisture characteristic curves that are fit to data reported on p. 18 of the report;
4) Justify the use of logarithmic averages for recommended hydraulic property values on p. 19 of the report; and
5) Provide an up to date copy of the PA maintenance plan.

A follow-up action identifies an information need or request that will help NRC staff determine whether a technical issue is risk significant and can warrant tracking as an open issue.

Open Issues

No open issues are identified as a result of this technical review at this time. However, as stated above, DOE has a number of follow-up actions resulting from the staff's questions on the report.

Conclusion

The NRC staff has not identified open issues associated with the methods and data reported in this report (SRNS-STI-2008-00421) at this time. However, DOE has several follow-up actions in response to staff questions. The staff plans to review any new information developed by DOE as part of these follow-up actions.

This report contains data that may be relied upon in future performance assessment (PA) updates in support of the 2005 DOE waste determination for the Saltstone Disposal Facility. However, until such time as a PA update is completed and reviewed by NRC staff, the staff cannot fully assess the risk significance of the data. For this reason, all monitoring activities identified under Factors 1-3 of the NRC monitoring plan remain open at this time.

September 1, 2009

MEMORANDUM TO: Gregory Suber, Chief
Low-Level Waste Branch
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and Performance Assessment Directorate
Division of Waste Management
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Office of Federal and State Materials
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THRU: Christepher McKenney, Chief **/RA/ by K. Pinkston for**
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FROM: David Esh, Sr. Systems Performance Analyst **/RA/**
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SUBJECT: TECHNICAL REVIEW: "EVALUATION OF SULFATE ATTACK ON SALTSTONE VAULT CONCRETE AND SALTSTONE, PART I: FINAL REPORT", "EVALUATION OF SULFATE ATTACK ON SALTSTONE VAULT CONCRETE AND SALTSTONE, PART II: TEST METHODS TO SUPPORT MOISTURE AND IONIC TRANSPORT MODELING USING THE STADIUM® CODE"

On January 9, 2009, the U.S. Department of Energy, Savannah River Operations Office, provided the subject report for review by U.S. Nuclear Regulatory Commission (NRC) staff pursuant to Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005. The subject reports are available on NRC's Agencywide Documents Access and Management System (ADAMS) at accession numbers ML090150306 and ML090150312. These reports were reviewed in accordance with monitoring activities described in "U.S. Nuclear

Regulatory Commission Plan for Monitoring the U.S. Department of Energy Salt Waste Disposal at the Savannah River Site in Accordance with the National Defense Authorization Act for Fiscal Year 2005" (ML070730363). The staff's technical review summary is attached for your use.

Docket No.: PROJ0734

Enclosure: Technical Review Summary

Technical Review Summary: *"EVALUATION OF SULFATE ATTACK ON SALTSTONE VAULT CONCRETE AND SALTSTONE, PART I: FINAL REPORT", "EVALUATION OF SULFATE ATTACK ON SALTSTONE VAULT CONCRETE AND SALTSTONE, PART II: TEST METHODS TO SUPPORT MOISTURE AND IONIC TRANSPORT MODELING USING THE STADIUM® CODE"*

Review Completed: June 24, 2009

Reviewer(s): D. Esh

Document(s): Langton, C. A., *Evaluation of Sulfate Attack on Saltstone Vault Concrete and Saltstone, Part I: Final Report*, SRNS-STI-2008-00050, Revision 0, SimCo Technologies Inc. for Savannah River National Laboratory, SRNS. August 2008, ADAMS accession no. ML090150306

Langton, C. A., *Evaluation of Sulfate Attack on Saltstone Vault Concrete and Saltstone, Part II: Test Methods to Support Moisture and Ionic Transport Modeling Using the STADIUM® Code*, SRNS-STI-2008-00052, Revision 0, SimCo Technologies Inc. for Savannah River National Laboratory, SRNS. August 2008, ADAMS accession no. ML090150312

Evaluation

The reports provide preliminary results to assess the effects of contacting saltstone vault concretes with highly alkaline solutions containing high concentrations of dissolved sulfate. Part I provides the description of and results from numerical simulations, whereas Part II provides a description of the test methods used to develop information to support the numerical modeling. Part I provides results for two surrogate concretes that were used in the preliminary durability analysis. The modeling provided key inputs for the current performance assessment (PA) analysis including but not limited to:

- The relationship between the rate of advancement of the sulfate front and the rate of change of the concrete permeability and diffusivity.
- The relationship between the sulfate ion concentration in the corrosive leachate and the rate of the sulfate front progression, and
- An equation describing the change in hydraulic properties as a function of sulfate ion concentration in the corrosive leachate.

The STADIUM® code and data from two surrogate concretes were used in the preliminary durability analysis. Validation of the results was completed for surrogate concretes. Measurements on SRS Vault 1/4 and Disposal Unit 2 concrete samples are being performed and the analysis will be revised when they are available. Modeling of and measurements on saltstone are also being performed. In addition, sulfate exposure tests of Vaults 1/4 and Disposal Unit 2 concrete samples to three alkaline, high sulfate leachates is underway to validate the predicted results. A revised report is expected to be available September 2009.

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The saltstone wasteform is cast in concrete vaults. The vaults provide a barrier to movement of deleterious groundwater species into the saltstone wasteform and a barrier to migration of radionuclides in the saltstone wasteform to the environment. The studies were performed because the saltstone wasteform contains high concentrations of sulfate. Sulfate could diffuse into the vault concrete and deteriorate its performance. The measurements, analysis, and modeling were performed to estimate the degradation of the concrete over 10,000 years. The STADIUM® code is an ionic transport model that accounts for electrical coupling, chemical activity, and transport due to water gradients and temperature. The model also includes a chemical equilibrium module.

Overall the analysis and supporting measurements represented a well-designed evaluation of the potential for sulfate attack using best available technology. Three cases are evaluated: case 1 – saltstone pore water (undiluted), case 2 – saltstone pore water diluted 10:1, and case 3 – leached saltstone pore water at 10:1 dilution. Table 3-1 of the report provides previously measured saltstone pore solutions and Table 3-2 provides the values used in the simulations. The cases selected are reasonable, although, as noted in the report, the concentration of sulfate used is approximately 20% less than experimentally measured values. Experimental validation, when completed, will ensure the simulations are realistic. The U.S. Nuclear Regulatory Commission (NRC) staff will review the results of those experiments when they are available. For exposure to high sulfate concentrations (Case 1), the ettringite front was estimated to penetrate a 20 cm vault wall in about 5000 years. For cases 2 and 3 the ettringite front was estimated to penetrate approximately 40% and 20% of the vault thickness, respectively. The report discussed a number of uncertainties, such as the effect of micro cracks and macro cracks. Macro cracks (greater than 100 μm) in concrete have been previously observed to result in saturated diffusion coefficients corresponding to those reported for free water which represents about a factor of 50 increase.

Section 7.0 of Part I of the report provides a description of how the results will be abstracted for use in the PA. NRC generally agrees with the outlined approach, although modifications may be necessary when the experimental measurements are completed.

The NRC staff observes that the following areas may need to be considered by the Department of Energy (DOE) as part of model abstraction in the PA, depending on the degree to which the performance of saltstone grout, Vault 1/4 concrete, and Disposal Unit 2 is relied upon against degradation by sulfate attack: 1) consideration of fast pathways (e.g., cracks) for sulfate penetration and associated higher localized degradation, 2) new information on bulk properties of the vaults and saltstone grout, and 3) coupling of damage to reaction/transport. Each of these items is described below in more detail. NRC recognizes that the first two items would likely be addressed in the PA revision. Other questions were communicated to DOE during the March 25-26, 2009 onsite observation meeting. Those are listed in the "Teleconferences and Meetings" section of this report and are summarized below, as needed.

This study used an idealized and simplified conceptual model with one-dimensional transport for front propagation. Vaults 1 and 4 are known to have a number of imperfections (cracks, pathways around pipes or other discrete features) that would likely provide faster diffusion rates of sulfate. The calculated penetrated (degraded) wall fraction as a function of time in the PA should account for diffusion into the vault concrete (perpendicular to what is currently evaluated) at these imperfections and other features. This approach would result in earlier penetration of some fraction of the vault wall and formation of highly-permeable pathways consistent with the damaged state of the material.

This study included measurements of the ionic diffusivity for small-scale, laboratory-prepared samples. The staff concludes that the bulk properties of the as-built materials may be significantly different due to scale, quality, or other issues. The sulfate attack and secondary phase formation processes occur at the pore and grain scale of the material. However, as discussed in these reports, the presence of macroscopic features can significantly influence the effective properties of the materials. The sulfate attack simulations should address uncertainty in the bulk properties of the as-built materials (compared to the laboratory measurements of surrogate samples used to support the analysis). At a minimum, the abstraction for the PA should include the diffusivity of the concrete as a variable.

This study did not assign higher diffusivity to the damaged region of the concrete. As the concrete is damaged, the diffusivity of the damaged region could increase resulting in a higher rate of front propagation. This effect may not be resolvable in short duration experiments because the derivative of the rate of front propagation may not be observable on the scale of such experiments. It is recommended that additional simulations be performed where the diffusivity of the degraded region is increased appropriately, and that those simulations are compared to the current simulations for common sets of input.

DOE should include uncertainty in the PA abstraction that is developed from this study. NRC staff will evaluate the revised saltstone PA when it is available.

Teleconferences and Meetings

The subject report was discussed with representatives of the DOE and its contractors on March 25-26, 2009 at the onsite observation conducted at the Savannah River Site. A summary of the discussion is provided in the onsite observation report (ADAMS accession no. ML091320439). The follow-up actions as a result of the discussion were:

1) Evaluate the sensitivity of grid spacing to predicted front propagation in the sulfate attack evaluation.

2) Explain how spatial representation in the numerical experiments of sulfate attack will be translated into a PA model, since the geometries of the real system will be much more complex (e.g., a random collection of different size blocks determined by crack distributions) than those considered in the numerical experiments.

3) Explain how cracks are incorporated into the sulfate attack representation in the PA model, since cracks could significantly impact the degradation assessment (page 15). Explain assumption i that the transport rate of sulfate ions through damaged concrete is not different from undamaged concrete (page 21).

4) Clarify the conceptual model for sulfate attack. For example, does sulfate attack proceed along a front, or is it a generalized mechanism.

5) Clarify the conceptual model represented by case 2 (page 6). If the concentration was diluted by diffusion, then what is the fate of diffused species? If species are diffusing through the vault wall, then why isn't the vault wall degraded.

6) Explain why it is appropriate to neglect minor species (page A2-14).

7) Justify the use of Berner's approach for these materials and solutions (page A2-15).

Open Issues

No open issues were identified as a result of the review, however as indicated above a number of follow-up actions were identified.

Conclusion

The NRC staff has not identified open issues associated with the methods and data reported in this study at this time. However, DOE has several follow-up actions in response to staff questions. The staff plans to review any new information developed by DOE as part of these follow-up actions.

This study contains data that will be relied upon in future performance assessment updates in support of the 2005 DOE waste determination for the Saltstone Disposal Facility. However, until such time as a PA update is completed and reviewed by NRC staff, the staff cannot fully assess the risk significance of the information. For this reason, all monitoring activities identified under Factors 1-3 of the NRC monitoring plan remain open at this time.

September 1, 2009

MEMORANDUM TO: Gregory Suber, Chief
Low-Level Waste Branch
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

THRU: Christepher McKenney, Chief **/RA/ by K. Pinkston for**
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FROM: David Esh, Sr. Systems Performance Analyst **/RA/**
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SUBJECT: TECHNICAL REVIEW: SOIL CONTAMINATION DATA AND ASSOCIATED ANALYSIS FOR VAULT 4 OF THE SALTSTONE DISPOSAL FACILITY

On January 8, 2009, the U.S. Department of Energy, Savannah River Operations Office, provided reports describing soil sampling and associated analysis for soil contamination in the vicinity of Vault 4 of the saltstone disposal facility for review by the Nuclear Regulatory Commission (NRC) staff pursuant to Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005. The subject reports are available on NRC's Agencywide Documents Access and Management System (ADAMS) at accession numbers ML090120429, ML090120404, ML090120475, ML090120546, and ML090120539. These reports were reviewed in accordance with monitoring activities described in "U.S. Nuclear Regulatory Commission Plan for Monitoring the U.S. Department of Energy Salt Waste Disposal at the Savannah River Site in Accordance with the National Defense Authorization Act for Fiscal Year 2005" (ML070730363). The staff's technical review summary is attached for your use.

Docket No.: PROJ0734

Enclosure: Technical Review Summary

TECHNICAL REVIEW SUMMARY: *SOIL CONTAMINATION DATA AND ASSOCIATED ANALYSIS FOR VAULT 4 OF THE SALTSTONE DISPOSAL FACILITY*

Review Completed: July 2, 2009

Reviewer(s): D. Esh

Document(s):

Rosenberger, K. H., *Comparison of Vault 4 Soil Sampling Results to Existing Unreviewed Disposal Question Evaluation*, SRS-REG-2007-00041, SRNS-J2100-2008-00013, Savannah River Nuclear Solutions. December, 2008b. ADAMS Accession # ML090120429

Kubilius, W., *Z-area Vault 4 Phase 2 Soil Sample Analytical Data Report*, ERD-EN-2008-0083, Savannah River Site, December 2008. ADAMS Accession # ML090120404

Rosenberger, K. H., *Unreviewed Disposal Question Evaluation: Evaluation of Liquid Weeping from Saltstone Vault 4 Exterior Walls*, SRS-REG-2007-00041, Revision 1, Westinghouse Savannah River Company, Aiken, South Carolina, April 2008a. ADAMS Accession # ML090120475

Kent, E., *Letter to J. Buczek, WSRC, re: Samples received on February 14, 2008*, GEL Laboratories, March, 2008. ADAMS Accession # ML090120546

Kent, E., Letter to J. Buczek, *WSRC, re: Samples received on July 16, 2008*, GEL Laboratories, September, 2008. ADAMS Accession # ML090120539

Evaluation

The reports provide data from sampling and associated analysis of soil contamination that occurred outside of Cell E of Vault 4 at the Saltstone Disposal Facility (SDF). The soil contamination resulted from active weep sites in the exterior vault wall and at the joint between the vault wall and wall floor. The Department of Energy (DOE) collected samples and performed analysis to determine the magnitude and spatial extent of contamination (Kubilius, 2008). DOE concluded that a very large fraction (> 99%) of the contamination was located within 2 feet (0.6 m) of the release points. In addition, the Unreviewed Disposal Question Evaluation (UDQE) evaluation concluded that there was no significant impact to public health and safety due to an assumed release of up to 1000 liters of undiluted salt solution (Rosenberger, 2008a). This review documents the U.S. Nuclear Regulatory Commission (NRC) staff evaluation of the sampling, analysis, and evaluation. As previously noted by NRC staff in the March 2008 onsite observation report (ML081290367), staff agreed that the risk from leakage from the vaults during operations had been appropriately assessed by DOE and that the performance objectives were likely to continue to be met. However, substantial increases in

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the expected inventory that has been released or the concentration of that inventory could invalidate that conclusion. Based on current information, the risks are likely limited and public health and safety continues to be protected.

Soil sampling was conducted in two phases, and the second phase had two objectives, 1) to investigate the spatial extent of the most contaminated area sampled by Phase 1 (location ZV4-002 at Cell E) and 2) to obtain I-129 data. Samples were collected at a variety of locations and up to five different depth intervals. Figures 2 and 3 of (Kubilius, 2008) provide illustrations of the sampling locations. The shallowest sample depth comprised the 0 to 3 inch (0 to 8 cm) depth interval. Samples were analyzed for nitrate and a limited suite of radiological constituents, including gross alpha, nonvolatile beta, C-14, Sr-90, Tc-99, Sb-125, I-129, and Cs-137. The sample results for Cs-137 showed the highest concentrations were closest to the walls and at the shallowest sample depths. NRC staff believes the fact that contamination was found a much more significant distance laterally from the walls (> 3 m) compared to depth suggests surface runoff and stormwater flow was the dominant redistribution process.

The vaults contain concrete footers which extend into the soil approximately 0.6 m from the vault walls. Sampling was performed above and adjacent to the footers, but not underneath. During the March 25-26, 2009 monitoring visit, NRC and DOE staff discussed whether the floor and footers of the vaults could have active weep sites. DOE explained that the causes of the discontinuities in the vault walls were not anticipated in the floors, and that the groundwater sampling plan would identify any releases. Therefore direct soil sampling was not necessary. NRC staff noted that the potential for releases through the vault floors could be much higher, as a result of the larger surface area and continual presence of a hydrostatic head, but otherwise agreed with the DOE conclusion. Sample results for nitrate, which is more mobile, showed maximum concentrations in the 12-24 inch (30-60 cm) or 24-48 inch (60-120 cm) depth intervals. DOE experienced problems with the radiological analysis for I-129. Initially, the laboratory contracted to perform the analysis failed to perform a separation of Cs-137, which made the sample results inconclusive. After the error was recognized, the separation was performed but by that time the maximum holding time of 28 days for iodine-129 analysis had been exceeded.

In (Rosenberger, 2008b) DOE evaluated the soil sampling results with respect to the UDQE performed in April 2008 (Rosenberger, 2008a) and determined the previous evaluation bound the observed soil concentrations. The April 2008 UDQE evaluated the impact of the immediate release of 1000 L of concentrated salt solution to the environment. It employed the NCRP-123 screening methodology to evaluate potential impacts to groundwater. The results, combined with the groundwater sampling program, provided the basis for DOE to conclude that further soil sampling to obtain additional radionuclide concentrations was not warranted. As expressed at the March 25-26, 2009 monitoring visit, NRC staff does not agree with this conclusion. In (Rosenberger, 2008b) DOE used a comparison of the ratio of measured Tc-99 to Cs-137 in the salt solution used as feed for saltstone to the ratios observed in the soil samples to argue that further sampling for I-129 is not needed. DOE believed that because the Tc-99 to Cs-137 was reasonably in line with expectations and both Tc-99 and I-129 are relatively non-sorbing that I-129 should also be in a ratio in the soil similar to that in the salt solution.

NRC staff believes that while the elevated iodine-129 measurement could be an anomaly attributable to sample handling and analysis problems encountered in the laboratory, further investigation by DOE is warranted. The staff believes that differential sorption of radioelements in soil can confound the use of contaminant ratios to judge whether a contaminant should be expected in a given soil sample. In addition, the saltstone grout is designed to reduce technetium and result in low concentrations in solution, which would possibly further modify the ratio for Tc-99 to Cs-137 in saltstone bleedwater, as compared to the ratio in salt waste that has not contacted reducing constituents of the grout (i.e., blast furnace slag). The contaminant ratio argument is indirect, whereas the sampling results are direct (but as discussed above are suspect for current I-129 values due to laboratory analysis problems). For this issue, identification of a soil concentration limit and sampling to determine observed values are less than the limit is sufficient for NRC monitoring.

The contaminant ratio argument and (suspect) sample result can be in strong disagreement or can be in relative agreement depending on the inventory estimate that is used. The reported iodine-129 concentration in a phase 2 gravel sample from 3" to 12" (8 to 30 cm) in depth next to Cell E was 69 pCi/g (a 95 percent confidence interval, or uncertainty value, was not reported). The cesium-137 value for the corresponding phase 1 sample from the same depth and location was 11,700 pCi/g. Using these values, staff calculated a concentration ratio of Cs-137 to I-129 of about 170. Based on the Saltstone Performance Objective Demonstration Document (CBU-PIT-2005-00146, Rosenberger et al June 2005), the then current Vault 4 inventory of I-129 was 8.16E-2 Ci and the inventory of Cs-137 was 16.8 Ci, for a concentration ratio of about 200. This value is consistent with the observed soil concentration ratio.

Using expected SDF inventories cited in the salt waste performance assessment, the expected average Cs-137:I-129 ratio in salt waste is about 75,000 (The UDQE implies an Cs-137:I-129 ratio of 10,000,000:1). NRC staff believes that the reasons for the large difference between an expected Cs-137:I-129 ratio of 75,000 and an observed ratio of 170 should be thoroughly understood by DOE. In addition, the difference between the salt waste performance assessment value (75,000) and the UDQE value (10,000,000) should be clearly described.

The use of contaminant ratios assumes that the contaminants are transported in the environment at the same rate (or are equally sorbing). As noted previously, nitrate (and Tc-99 and I-129) has a significantly different affinity for sorption to soil compared to Cs-137. The UDQE used a Kd for Cs-137 of 50 ml/g and a value of 0.0 ml/g for I-129. I-129 has the potential to exceed the > 2.5 mrem screening criteria used in the UDQE if the inventory was significantly different than anticipated (This is one possible explanation of the I-129 soil sample results). Using information from Table 3 of the UDQE (Rosenberger, 2008a), staff estimate that an I-129 release of 0.002 Ci would exceed the 2.5 mrem screening criteria based on the DOE UDQE analysis.

Teleconferences and Meetings

The subject reports were discussed with representatives of the Department of Energy and its contractors on March 25-26, 2009 at the onsite observation conducted at the Savannah River Site. A summary of the discussion is provided in the onsite observation report (ADAMS accession no. ML091320439). The follow-up action as a result of the discussion was:

1) DOE should continue to investigate the source of iodine-129 detected in soil samples.

Open Issues

No open issues were identified as a result of the review, however as indicated above a follow-up action was identified.

Conclusion

The NRC staff has not identified open issues associated with the methods and data reported in this study at this time. However, DOE has a follow-up action in response to staff questions. The staff plans to review any new information developed by DOE as part of this follow-up action.

This study contains data that may be relied upon in future performance assessment (PA) updates in support of the 2005 DOE waste determination for the Saltstone Disposal Facility. The revised saltstone performance assessment is expected to include the observed locations and form of contamination identified during disposal system operation and monitoring. However, until such time as a PA update is completed and reviewed by NRC staff, the staff cannot fully assess the risk significance of the information. For this reason, all monitoring activities identified under Factors 1-3 of the NRC monitoring plan remain open at this time.

October 23, 2009

MEMORANDUM TO:	Gregory Suber, Chief Low-Level Waste Branch Environmental Protection and Performance Assessment Directorate Division of Waste Management and Environmental Protection Office of Federal and State Materials and Environmental Management Programs
THRU:	Christepher McKenney, Chief **/RA/** Performance Assessment Branch Environmental Protection and Performance Assessment Directorate Division of Waste Management and Environmental Protection Office of Federal and State Materials and Environmental Management Programs
FROM:	Karen Pinkston, Systems Performance Analyst Performance Assessment Branch Environmental Protection and Performance Assessment Directorate Division of Waste Management and Environmental Protection Office of Federal and State Materials and Environmental Management Programs
SUBJECT:	TECHNICAL REVIEW: SALTSTONE AND CONCRETE INTERACTIONS WITH RADIONUCLIDES: SORPTION (K_d), DESORPTION, AND REDUCTION CAPACITY MEASUREMENTS

On January 9, 2009, the U.S. Department of Energy, Savannah River Operations Office, provided the subject report for review by U.S. Nuclear Regulatory Commission staff (NRC) pursuant to Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005. The subject report is available on NRC's Agencywide Documents Access and Management System (ADAMS) at accession number ML090150234. This report was reviewed in accordance with monitoring activities described in "U.S. Nuclear Regulatory

Commission Plan for Monitoring the U.S. Department of Energy Salt Waste Disposal at the Savannah River Site in Accordance with the National Defense Authorization Act for Fiscal Year 2005" (ML070730363). The staff's technical review summary is attached for your use.

Docket No: PROJ0734

Enclosure: Technical Review Summary

Technical Review Summary: TECHNICAL REVIEW: "SALTSTONE AND CONCRETE INTERACTIONS WITH RADIONUCLIDES: SORPTION (K_d), DESORPTION, AND REDUCTION CAPACITY MEASUREMENTS"

Review Completed: October 2009

Reviewer(s): K. Pinkston, D. Pickett

Document(s): Kaplan, D.I., Roberts, K., Coates, J., Siegfried, M., Serkiz, S., *Saltstone and Concrete Interactions with Radionuclides: Sorption (K_d), Desorption, and Reduction Capacity Measurements*, SRNS-STI-2008-00045, Savannah River Nuclear Solutions. October, 2008. ADAMS Accession # ML090150234

Evaluation

The paper "Saltstone and Concrete Interactions with Radionuclides: Sorption (K_d), Desorption, and Reduction Capacity Measurements" by Kaplan et al. describes the results of experiments performed to provide additional data and model support for the performance assessment for the Saltstone Disposal Facility (SDF). This research includes the measurement of K_d values for the sorption of radionuclides on simulated saltstone and Vault 2 concrete, the adsorption and desorption rates, and the measurement of the reduction capacity of simulated saltstone. Nuclear Regulatory Commission (NRC) staff had the opportunity to discuss and observe these experiments during an onsite observation visit to the Savannah River Site (SRS) on July 31, 2008. The onsite observation report for this can be found at NRC's Agencywide Documents Access and Management System (ADAMS) Accession # ML082530057.

The simulated saltstone material was made with a non-radiologically contaminated feed solution. In most cases, a simulated waste stream from the Deliquification, Dissolution, and Adjustment (DDA) process was used to create this material because this waste stream was believed to be most representative of the waste stream that is going to be disposed of at the SDF. Different leaching solutions were used to simulate different stages of the cement aging process. A portlandite saturated solution was used to simulate the first two stages of cement aging, and a calcite saturated solution was used to simulate the third stage of cement aging. The first stage of cement aging occurs immediately after the cement hardens and is characterized by high pH (>12.5), high ionic strength, the dissolution of alkali impurities, and the formation of CSH gels. The second stage of cement occurs after all of the alkali salts have been dissolved and the pH is controlled to a value of 12.5 by portlandite. In the third stage, all of the portlandite has been dissolved, the CSH gels begin to dissolve, and the pH begins decreasing.

This research was intended to gain understanding about how the radionuclides will interact with the saltstone material and vault concrete once the radionuclides have leached out of the saltstone. These studies do not address how the radionuclides are bound in the saltstone during curing, and these studies do not provide information on how the radionuclides will be leached from saltstone.

Enclosure

K_d Value Measurements

The solid-water distribution ratios, or K_d values, were measured for both simulated saltstone and Vault 2 concrete using batch sorption studies for I-125, Np-237, Se-75, Pa-231, Pu-238, Tc-99, U-233, and a suite of radionuclides that can be measured with gamma spectroscopy that included Am-241, Cd-109, Ce-139, Co-60, Cs-137, Hg-230, Sn-113, Sr-89, and Y-88. Measurements were made with leaching solutions that simulated both cement early in the aging process and aged cement. Additionally, measurements were made for DDA simulated saltstone under both oxidizing and reducing conditions.

The results of these experiments are presented in Tables 2 and 3. Data were not obtained for uranium because of analytical problems associated with the measurements for uranium. Additionally, a problem with precipitation of the radionuclides occurred in the no solids control sample for the suite of gamma-emitting radionuclides. The no solids control sample contained either the portlandite or calcite saturated solution and the radionuclides without the vault concrete or simulated saltstone solids. The purpose of the no solids control sample was to determine if there was a loss of radionuclides through a mechanism other than sorption onto the cementitious material, such as precipitation or sorption onto the vial.

The K_d values measured for Se, I, and Tc were lower than those reported in the literature. The lower K_d for Se was attributed to the activity of Se being near the detection limit. The measured Tc K_d values were several orders of magnitude lower than the literature value. This indicates that the Tc in these experiments was not reduced. The measured K_d values for Np and Pu were greater than previous measurements. Updated K_d values for I, Np, and Pu were recommended based on these results. The recommended K_d for iodine was changed from 2-10 mL/g to 5-9 mL/g for cement in the first two stages of aging, and from 4 mL/g to 0 mL/g for aged cement (i.e., stage 3). The recommended K_d values for Np and Pu were increased from the previous literature value. The recommended K_d value for Tc was not changed from the previous literature value of 5,000 mL/g.

NRC staff does not believe that the data from these experiments supports the continued use of the K_d value of 5,000 mL/g for Tc. Additionally, it is not clear if other literature on the K_d of Tc supports the use of this value for reducing grout. In the report by Bradbury and Sarott (1995), which was cited as the basis for the Tc K_d value in Kaplan and Coates (2007), a K_d value of 1 m^3/kg (1,000 mL/g) is recommended in Table 4. In section 5.2.10 of Bradbury and Sarott, work done by Bayliss et al. (1991) is cited in which a Tc K_d value of 5 m^3/kg (5,000 mL/g) was measured. However, this K_d value was measured in the presence of the sodium dithionite reducing agent, which is not present in saltstone, so it is not clear if this K_d value is applicable to this system. Understanding and correctly modeling the behavior of Tc is important because it significantly affects the performance and expected dose from this disposal system. As described in more detail below, the research at SRS on the K_d for Tc is ongoing. NRC staff believes that this research will be useful in addressing this issue.

Adsorption/Desorption Experiments

The rates of adsorption and desorption were measured to determine if the steady-state assumption was valid and to compare adsorption and desorption rates. The K_d approach commonly used in modeling environmental transport assumes that both rates are same.

The rate of adsorption of the radionuclides was measured for simulated vault 2 concrete and DDA simulant saltstone in batch experiments. As was true for the K_d experiments, the experiments with the gamma emitting suite of radionuclides had problems with precipitation of the radionuclides in the no solids controls. The rates of desorption were measured using columns packed with the Vault 2 concrete and saltstone material from the adsorption experiments. The concentrations of radionuclides in the column effluent were measured with a gamma detector.

The results of these experiments indicated that the rate of desorption was much slower than the rate of adsorption for the simulated Vault 2 concrete. However, NRC staff believes that the use of the solid samples (in which there may have been problems with precipitation) to measure the desorption rates may not have been appropriate because the measured rates of desorption may be attributable to dissolution rather than desorption. Additionally, the precipitation observed in the no solid control samples may be due to an artifact of the experimental design and may not represent a phenomenon that would occur in the actual disposal system.

The rates of sorption and desorption was also measured for Tc on DDA simulant saltstone and Vault 2 concrete in a calcite saturated solution. In these experiments, the solids and calcite solution were brought to equilibrium, and then $^{99}TcO_4^-$ was added. Samples were removed and analyzed over time. After two weeks, the liquid phase was removed and replaced with a solution that did not contain Tc-99. Samples were analyzed at different times over 26 days to measure the rate of desorption.

In these experiments, very little Tc-99 was sorbed by either the Vault 2 concrete or DDA simulant saltstone. The measured K_d values in this portion of the experiment were 13 mL/g for simulated saltstone and 28.1 mL/g for Vault 2 concrete. These values are in the same range as the K_d value of 6.5 mL/g measured in the K_d experiments described above. These results indicate that Tc(VII) was not reduced to Tc(IV) because, if reduction had occurred, the Tc would have precipitated and the apparent K_d value measured would have been much higher. These results are unexpected because the saltstone and Vault 2 concrete had large reduction capacities. It was hypothesized by the researchers that the length of the experiment was not long enough for reduction to occur.

These experiments also showed that Tc sorption occurred quickly, but the rate of desorption was much slower. The paper concludes that this fact implies that if the groundwater flows along a crack and by-passes the reduction capacity of Saltstone, the oxygenated water will not promote Tc desorption as much as is predicted based on the K_d value.

NRC staff believes that it is important to understand the behavior of Tc in saltstone because as stated above the behavior of this radionuclide can significantly affect the dose from this disposal system. NRC staff also believe that additional research is needed on the relative adsorption and desorption rates of Tc. Because the Tc was not reduced in these experiments, the rates of adsorption and desorption may not be applicable to a system in which it is reduced.

Reduction Capacity Measurements

The reduction capacity and redox conditions of saltstone over time is an important factor in the performance of the system. The environmental mobility of some radionuclides, such as Tc-99, is strongly dependent on its oxidation state. A previous long-term lysimeter study at SRS showed that the addition of blast furnace slag, which contains reductants iron(II) and sulfide, to saltstone limited the leaching of Tc-99.

In the research described in this paper, the reduction capacities were measured by a titration method for a variety of materials including: DDA simulant saltstone, Vault 2 concrete, blast furnace slag, subsurface sediments, and 50 year old SRS concrete. The measured reduction capacities of the DDA simulant saltstone and Vault 2 concrete were higher than expected based on the measured reduction capacity of the blast furnace slag. The measured reduction capacity of the blast furnace slag was 832.4 μeq/g, and the measured reduction capacity of the simulated saltstone, which only contains 23% blast furnace slag, was 821.8 μeq/g. Similarly, the reduction capacity of the vault concrete was 240 μeq/g, which was higher than expected based on the vault concrete containing 10% blast furnace slag by weight. Several hypotheses were proposed for the reduction capacity in the simulated saltstone and vault concrete being higher than expected including: the higher pH of saltstone than blast furnace slag causing more of the matrix to dissolve and more of the reducing agents to be available for reaction, the saltstone could be behaving like a semiconductor, the minerals in the fly ash could be adding additional reducing capacity, and the microporosity of saltstone could be higher than blast furnace slag, which would make a larger surface area available for reaction. These results could also be attributable to the cerium used in the titration method sorbing more strongly to the saltstone than the blast furnace slag, but this was thought to be a less likely explanation.

In addition to the reduction capacity, the redox state of the system was also investigated using a Eh probe. In this experiment, the pH and Eh were measured in the effluent from a column containing DDA simulant saltstone that had an air-sparged calcite solution passed through it. It was found that the pH value decreased with the volume of water that flowed through the system. The Eh value increased quickly to around 0 mV as the oxygenated water flowed through the column. Additional experiments showed that the Eh value decreased slightly after the flow through the column had been stopped for a period of 4-6 hours. This was attributed to the system not being at steady state. The flow rate of oxygenated water through the column was much faster than would be expected in the disposal system, and the kinetics of the reducing reactions may have been too slow to create reducing conditions in the column effluent. The ability of the saltstone in the actual system to maintain reducing conditions may be better than was seen in the column experiments.

NRC staff believes that the reduction capacity and redox state of the saltstone is an important factor in the long-term performance of the saltstone, and the research described in the subject paper is extremely useful to providing model support for the performance assessment. NRC staff noted that even though the measured reduction capacity of saltstone was high, the Eh was not poised to reducing conditions in the column experiments. NRC staff agree that this was likely attributable to the high flow rate through the columns, but it would be prudent for additional experiments to be performed to confirm that the Eh will be poised to reducing conditions in saltstone that has oxygenated water flowing through it.

Teleconferences and Meetings

NRC staff discussed the research and observed some of the experiments described in the subject report during a meeting on July 31, 2008 at SRS. This discussion is summarized in an onsite observation report (ADAMS accession # ML082530057).

The subject report was also discussed with representatives of the Department of Energy and its contractors on March 25-26, 2009 at the onsite observation conducted at the Savannah River Site (SRS). A summary of the discussion is provided in the onsite observation report (ADAMS Accession No. ML091320439). The follow-up actions as a result of the discussion were:

1. Explain what measures were taken to ensure that experiments with technetium were not affected by experimental losses, such as technetium holdup in labware, resulting in underestimates of technetium concentration.

2. Clarify the pH of the calcite solution used in these experiments (page 9 and 16 state the pH=10; page 7 states that solution pH = 8.3).

3. Clarify the selenium K_d value reported in Table 5, which is different than the value reported previously in the report.

SRS staff addressed these follow-up actions in a teleconference on August 5, 2009. The meeting summary for this teleconference and supporting documents are located in ADAMS at Accession # ML092650394. The response to action 1 was that non-sediment control samples were used as an internal control for experimental losses. Actions 2 and 3 were attributed to transcription errors. The correct pH value referred to in action 2 is 8.3, and the correct value for the selenium K_d for a Stage 3 concrete referred to in action 3 is 150 mL/g.

NRC staff found these responses to be acceptable, and these three follow-up actions were closed. However, NRC staff identified a new follow-up action based on the response to action 1:

ML092650394-001. Provide details on the amount of variability observed in the measured concentration of the non-sediment control sample (i.e. C_o in Attachment 3).

Open Issues

An open issue was identified related to the research described in the subject report during the March 25-26, 2009 onsite observation conducted at SRS (ML091320439):

Open Issue 2009-1

> At the SRS Saltstone Facility, DOE should demonstrate that (1) technetium-99 in salt waste is converted to its reduced chemical form in saltstone grout during the curing of saltstone grout, and is thereby strongly retained in saltstone grout, and (2) the sorption of dissolved technetium-99 onto saltstone grout and vault concrete is consistent with K_d values for technetium-99 that were assumed in the performance assessment.

SRS staff discussed their proposed approach to close this open issue during the August 5, 2009 teleconference. Their proposed approach involves performing additional testing on the saltstone reducing capacity and the K_d value of Tc-99. NRC staff agreed that the proposed approach seemed appropriate.

Conclusion

The research described in the subject report provides valuable information to support key parameters in the performance assessment. NRC staff also believes that the additional research being performed by SRS for the oxidation state and K_d value of Tc-99 in saltstone is appropriate and will provide useful information on the behavior of this radionuclide in this system.

References

Bradbury, M.H., Sarott, F.A., *Sorption Databases for the Cementitious Near-Field of a L/ILW Repository for Performance Assessment,* ISSN 1019-0643, PSI-Bericht Number 95-06. Paul Scherrer Institut. March, 1995.

Kaplan, D.I., Coates, J.M., *Partitioning of Dissolved Radionuclides to Concrete under Scenarios Appropriate for Tank Closure Performance Assessments,* WSRC-STI-2007-00640, Washington Savannah River Company. December, 2007.

November 9, 2009

MEMORANDUM TO: Gregory Suber, Chief
Low-Level Waste Branch
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

THRU: Christepher McKenney, Chief /RA/
Performance Assessment Branch
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
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FROM: Karen Pinkston, Systems Performance Analyst /RA/
Performance Assessment Branch
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

SUBJECT: TECHNICAL REVIEW: THERMODYNAMIC AND MASS BALANCE ANALYSIS OF EXPANSIVE PHASE PRECIPITATION IN SALTSTONE

On November 25, 2008, the U.S. Department of Energy, Savannah River Operations Office, provided the subject report for review by NRC staff pursuant to Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005. The subject report is available on NRC's Agencywide Documents Access and Management System (ADAMS) at accession number ML083400055. This report was reviewed in accordance with monitoring activities described in "U.S. Nuclear Regulatory Commission Plan for Monitoring the U.S. Department of Energy Salt Waste Disposal at the Savannah River Site in Accordance with the

National Defense Authorization Act for Fiscal Year 2005" (ML070730363). The staff's technical review summary is attached for your use.

Docket No.: PROJ0734
Enclosure: Technical Review Summary

TECHNCIAL REVIEW SUMMARY: "TECHNICAL REVIEW: THERMODYNAMIC AND MASS BALANCE ANALYSIS OF EXPANSIVE PHASE PRECIPITATION IN SALTSTONE"

Review Completed: November 2009

Reviewer(s): K. Pinkston, D. Pickett, G. Alexander, D. Esh

Document(s): Denham, M., *Thermodynamic and Mass Balance Analysis of Expansive Phase Precipitation in Saltstone*, WSRC-STI-2008-00236, Savannah River National Laboratory. May, 2008. Agencywide Documents Access and Management System (ADAMS) Accession # ML083400055

Evaluation:

The paper "*Thermodynamic and Mass Balance Analysis of Expansive Phase Precipitation in Saltstone*" by Denham described calculations performed to assess the potential for precipitation of expansive phases in saltstone. These expansive phases have higher molar volumes than normal cement minerals. The precipitation of these phases could cause fracturing that leads to a decrease in the performance of the wasteform by increasing advective flow and diffusion through it. For fracturing to occur, the amount of expansive phase minerals precipitated must exceed the ability of the porosity to accommodate the extra mineral volume, and the pressure caused by the expansive phase must be larger than the tensile strength of the cementitious material. The fraction of pore space that must be occupied before fracturing occurs is uncertain. A report by Tixier and Mobasher (2003) states that this fraction ranged from 0.05 to 0.45 for different cements with a median of 0.3.

The net volume gain from the formation of the expansive phases depends on the specific reactions involved and on whether other solid phases are consumed in the reaction. In addition, a loss in water from the pore fluid by incorporation into expansive phases can occur. The flow of water out of the pores as expansive phases precipitate may also relieve some of the pressure caused by the expansive phases.

In the subject report, the Geochemists Workbench® software was used to evaluate the potential for expansive phases to be formed in saltstone. Cement phases, including Ca-carboaluminate, CSH, C4AH13, ettringite, hyrdrogarnet, hydrotalcite, monosulfate, and mullite, were added to the thermodynamic database, and phases that are not typical of cements were removed from consideration. The phases allowed to precipitate included brucite, C4AH13, CSH, ettringite, gibbsite, gypsum, hydrogarnet, hydrotalcite, kaolinite, monosulfate, and quartz. The calculations were based on thermodynamic equilibrium, and kinetics were not considered. The calculations simulated the advective flow of fluid through a solid saltstone matrix in which the cement minerals were assumed to be evenly distributed. It was assumed that each new pore volume of fluid replaced the previous one with no mixing, and the reaction of each new volume of pore fluid with the solid matrix was modeled. The mineral content of the solid matrix was tracked for each volume of pore fluid reacted.

Enclosure

The primary initial mineralogy of the saltstone assumed in these calculations was estimated based on a chemical analysis of hydrated cement (WSRC 1992). The constituents identified in this analysis were placed into phases that are typical of cement. These phases included CSH, gibbsite, hematite, hydrotalcite, gypsum, and quartz. Hematite and monosulfate were not included in the phases in saltstone that were available to react with pore fluid because they rendered the model unstable. The author did not believe that this would affect the results because the amount of hematite in the initial mineralogy for saltstone was small and not including monosulfate is a conservative assumption because the volume change from this pathway is much less than the volume change from the gibbsite pathway. Two alternative initial mineralogies were also considered. One of these scenarios was based on the pre-hydrated cement composition from WSRC (1992). The other scenario was based on compositions of the portland cement, fly ash, and slag from Harbour (2006) and the salt feed composition from Dixon et al. (2008).

Six different scenarios were analyzed that considered different amounts of minerals available for reaction, different infiltrating solutions, and different initial saltstone formulations. Scenarios 1-3 used the saltstone formulation estimated based on the chemical analysis of hydrated cement. The infiltrating solution was rainwater that had been equilibrated with vault cement. Scenario 1 assumed that 10% of the minerals were available for reaction, Scenario 2 assumed 50% of the minerals were available, and Scenario 3 assumed that 100% were available. Scenario 4 also assumed an initial saltstone formulation based on the hydrated cement and 100% of the minerals being available for reaction, but in this scenario the infiltrating water was rainwater. Scenario 5 assumed an initial saltstone formulation based on pre-hydrated cement, 100% of the minerals being available for reaction, and used rainwater that was equilibrated with vault cement as the infiltrating fluid. Scenario 6 also assumed that 100% of the minerals were available for reaction and used rainwater that was equilibrated with vault cement as the infiltrating fluid, but in this scenario, the initial saltstone formulation was based on Harbour (2006) and Dixon et al. (2008).

In the Scenario 1 calculations, the expansive phase ettringite was oversaturated in the initial pore solution. The ettringite reacts with kaolinite over the initial pore volumes. The volume of ettringite then remains approximately constant for the remainder of the simulation. Another potentially expansive phase, C4AH13, was formed from the reaction of CSH and gibbsite. The calculations for Scenarios 2 and 3 had similar results, except the volume of C4AH13 increased as the fraction of minerals available for reaction. The number of pore volumes before ettringite dissolution stopped and C4AH13 precipitation began also increased as the fraction of minerals available for reaction increased. In Scenario 4, in which the infiltrating water is rainwater that has not been equilibrated with cement, the calculations predicted the minerals dissolving and a net mineral loss occurring. In Scenarios 5 and 6, in which alternative saltstone mineralogies were evaluated, the ettringite is predicted to dissolve initially and to re-precipitate later in the simulation. C4AH13 precipitation occurred after more pore volumes than in the other scenarios and the volume of C4AH13 formed is larger. The maximum amount of porosity loss due to expansive phase precipitation was observed in Scenario 6.

Based on these results, the author concluded that the fracturing of saltstone by expansive phases is unlikely because the maximum calculated loss in porosity was only 34%. This is slightly above the median value from Tixier and Mobasher (2003) for the amount of porosity that must be filled before fracturing occurs. The results also indicate that the amount of minerals available for reaction is an important factor in the amount of expansive phase formed, with the maximum amount being formed when 100% of the minerals are available for reaction. The amount of minerals in the saltstone matrix that would be available for reaction is not well known. The mineralogy of the saltstone matrix also affects the results. In the two scenarios where alternate mineralogy was assumed (Scenarios 5 and 6), more of the expansive phase C4AH13 was formed. The composition of the infiltrating water also affected the results. In the scenario where the water had not been equilibrated with the vault cement, dissolution of the minerals occurred instead of precipitation of expansive phases.

The author identified several areas of uncertainties in this research. The first area of uncertainty was that in this research the pore fluid composition was assumed to remain constant, but it is likely that the pore fluid composition of water infiltrating through the vault concrete would change over time as the vault concrete aged. This may be a conservative assumption because pore fluid in equilibrium with aged concrete would likely have a lower pH and calcium concentration, which would likely result in less precipitation in the saltstone. Another uncertainty identified was that this research only considered the equilibrium case and kinetics were not included. There is also uncertainty in the fraction of the porosity that must be filled before fractures happen and in the long term behavior of gels. Finally, in this research, the minerals are assumed to be homogeneously distributed within the saltstone wasteform. If they are heterogeneously distributed, some pore space might be filled to a greater extent than others.

Nuclear Regulatory Commission (NRC) staff believes that this research is a good first step in developing an understanding of the potential for expansive phases to form in saltstone. In addition to the uncertainties with this research identified by the author, NRC staff also believes that there is some uncertainty associated with the selection of minerals present in the saltstone wasteform and the minerals allowed to precipitate. NRC staff also believes that there is uncertainty associated with the effect of additives and pozzolans on the dissolution and precipitation reactions. NRC staff believes that comparisons of the modeling calculations to measured data would be useful, especially data that help to constrain key uncertainties, such as the amount of porosity that must be filled before fracturing occurs, the mineralogy of the saltstone wasteform, and the percent of minerals available for reaction.

Teleconferences and Meetings:

On June 16, 2009, NRC staff provided the following questions and topics of discussion to the Department of Energy (DOE) about the subject paper.

1. **Selection of Minerals**

   What was the basis for choosing the solid phases included in the initial saltstone normative composition (Table 3) and the suite of minerals that were allowed to precipitate in the saltstone (Table 6)? Specifically, what was the basis for including gibbsite, quartz, and kaolinite in these sets of phases? Kaolinite was included in the allowed precipitates (Table 6) despite the report's argument (in the preceding paragraph) that clays should not be included. These phases are important to some of the report's modeled reactions that involve the precipitation or dissolution of expansive phases. For example, a reaction on page 14 suggests that ettringite (a high-molar-volume phase) is consumed by reaction with kaolinite. What effect does the inclusion of gibbsite, quartz, and kaolinite in the solid phases have on the results obtained?

2. **Comparison of Results to Measured Data**

   What data and observations are available to compare to and constrain the modeling calculations?

3. **Additives and Pozzolans**

   This study does not consider the effects of organic additives or pozzolanic replacement on the dissolution and precipitation of cement-related compounds. These components of concrete and grout may have an effect on the generation of expansive phases. For example, future studies could consider the effect that sulfide from the blast furnace slag might have on the phases and reactions present in this system.

4. **Constraint of Modeling Results**

   Geochemical modeling seems to have many unknowns (initial conditions, phase selection or suppression, fundamental thermodynamic data, kinetics) that would impact the confidence in any particular result. Experiments that are designed to collect data on initial mineralogical conditions, fundamental thermodynamic data and reaction kinetics would provide much needed model support for this study.

5. **Uncertainty**

   This study is a deterministic analysis. A probabilistic (stochastic) analysis would provide insights into the importance and sensitivity of the model results to certain thermodynamic or physical properties.

6. **Kinetics**

   Geochemists Workbench is based on an equilibrium reaction model. However, reaction kinetics could result in metastable products that are often associated with an increase in volume. Follow on studies might consider expansive phases produced by intermediate or metastable reaction products.

7. **Integration of this Research with Other Research**

   The staff observes that the conclusions reached in this study area could be integrated with other ongoing or recently completed studies. Dixon (2008) recently completed a study on the physical properties of grout, which included bulk porosity measurements. Updated measurements of the bulk porosity of saltstone grout may be useful in assessing whether expansive phase precipitation is likely to result in grout degradation.

These topics were discussed with staff from the Savannah River Site (SRS) site during a teleconference on August 5, 2009. The meeting summary for this teleconference and supporting documents are located in ADAMS at Accession # ML092650394.

SRS staff addressed Comment 1 by stating that the gibbsite, quartz, and kaolinite phases were included to accommodate the high concentrations of silica and aluminum relative to calcium in saltstone. It was assumed that these phases would have fewer kinetic barriers to forming than more complex clays and zeolites. Additional Geochemist Workbench runs were performed, one in which more complex minerals were allowed to precipitate and one in which kaolinite and gibbsite were suppressed and excess aluminum was put in mullite. In both cases, no significant change in the amount of minerals precipitated was observed, so these runs did not change the conclusions of the report. NRC staff asked if these results had been published, and SRS staff stated that they had not. SRS staff addressed Comments 2-7 by stating that the research documented in this report was the initial step in trying to understand expansive phase precipitation during saltstone evolution and that additional research is ongoing. NRC staff found these answers to be reasonable, but cautioned that use of research as support for assumptions and parameters in performance assessments should be consistent with the maturity of the research.

Open Issues:

No open issues were identified as part of this review.

Conclusion:

The research described in the subject paper was a useful first step in evaluating the potential for cracking of saltstone to be caused by the precipitation of expansive phases. The additional research that is ongoing on this topic will provide useful information on the expected long-term performance of the saltstone wasteform and will constrain some of the uncertainty associated with this topic. In addition, because this research only considers fractures due to the precipitation of expansive phases, research on other possible mechanisms of fracturing could be useful.

NRC staff believes that it is important for the use of research in developing a conceptual model or parameters for a performance assessment to be consistent with the maturity of the research and for the uncertainty associated with the results to be adequately accounted for. NRC staff also believes that it is important for the research that is being done in support of the performance assessment to be well integrated.

References:

Dixon, K.L., Phifer M.A., and Harbour J.R., *Task Technical and QA Plan: Saltstone Grout and Vault Concrete Sample Preparation and Testing,* WSRC-TR-2008-00037. Washington Savannah River Company, 2008.

Harbour, J.R., Hansen, E.K., Edwards, T.B., Williams, V.J., Eibling, R.E., Best, D.R., and Missimer, D.M., *Characterization of Slag, Fly Ash, and Portland Cement for Saltstone,* WSRC-TR-2006-00067, Washington Savannah River Company, 2006.

Tixier, R. and Mobasher B., *Modeling of damage in cement-based materials subjected to external sulfate attack. II: Comparison with experiments.* Journal of Materials in Civil Engineering, 15, 314-322. 2003.

WSRC. *Radiological Performance assessment for the Z-Area Saltstone Disposal Facility*, WSRC-RP-92-1360, Westinghouse Savannah River Company. 1992.

November 12, 2009

MEMORANDUM TO: Gregory Suber, Chief
Low-Level Waste Branch
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

THRU: Christopher McKenney, Chief **/RA/**
Performance Assessment Branch
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

FROM: David Esh, Senior Systems Performance Analyst **/RA/**
Performance Assessment Branch
Environmental Protection
and Performance Assessment Directorate
Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs

SUBJECT: TECHNICAL REVIEW: SALTSTONE VAULT #2 INTERIOR LINING REVIEW

On November 25, 2008, the U.S. Department of Energy (DOE), Savannah River Operations Office, provided the subject report for review by the U.S. Nuclear Regulatory Commission (NRC) staff pursuant to Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005. The subject report is available on NRC's Agencywide Documents Access and Management System at accession number ML083400060. This report was reviewed in accordance with monitoring activities described in "NRC Plan for Monitoring the DOE Salt Waste Disposal at the Savannah River Site in Accordance with the

National Defense Authorization Act for Fiscal Year 2005" (ML070730363). The staff's technical review summary is enclosed for your use.

Docket No.: PROJ0734
Enclosure: Technical Review Summary

Technical Review Summary
SALTSTONE VAULT #2 INTERIOR LINING REVIEW

Review Completed: November 2009

Reviewer(s): D. Esh

Document(s): T.E. Skidmore, and K.D. Billings, *Saltstone Vault #2 Interior Lining Review*, WSRC-TR-2008-00090, Rev. 0, Savannah River National Laboratory. May, 2008. ADAMS Accession # ML083400060

Evaluation

The subject report provided a review of lining options for the interior of the new Saltstone Vault #2 design. The objectives for the lining materials are to improve the probability that the new vault design will meet long-term performance goals in a 10,000 year performance period by protecting the concrete vault from sulfate attack and other degradation mechanisms associated primarily with the initial interaction of the vault concrete with the saltstone wasteform. The desired service life of the materials selected is 100 years, because current DOE analysis suggests the impact of sulfate-containing bleedwater decreases as the bleedwater is removed from the system as the saltstone cures.

The report provides an overview of the vault lining requirements and saltstone characteristics. The primary function of the lining materials is mitigation of sulfate attack from short-term saltstone bleedwater (10,900 mg/L SO_4^-) penetration through surface cracks and by capillary suction, and diffusion of sulfate from the pore fluid of the cured saltstone. The coating must be resistant to chemical and radiation damage at elevated temperatures. In addition, the coating should exhibit a minimum elongation value of 2%, provide a long-term barrier for diffusion, be easily applied to joints and penetrations, and generate limited amounts of flammable gases. The report provides physical characteristics of saltstone, referencing the 1992 performance assessment. More recent data is acknowledged, though a reference is not provided. Although the physical characteristics of saltstone are not essential to the content of this report, they may influence the preliminary assessment performed in 2007 (reference 1 in the document) which identified the desired service life. If this report were to be revised, U.S. Nuclear Regulatory Commission (NRC) staff recommends that more recent information for the physical characteristics of saltstone be provided and that the assessment of the impact of liner coatings on preventing, mitigating, or delaying sulfate attack of concrete be reevaluated.

The impact of radiation on different liner materials was evaluated. Cs-137 was the primary contributor to the total dose rate from all radionuclides. The Cs-137/Ba-137m concentration was assumed to be 0.1 Ci/gal. From review of saltstone inventory reports, NRC staff concludes that the assumption of 0.1 Ci/gal may not be realistic or sufficiently conservative. Review of the saltstone inventory reports show that quarterly averaged concentrations of saltstone can exceed 0.15 Ci/gal. In addition, batch to batch variability would likely result in locally higher concentrations. NRC staff recommends that the assessment of radiation damage should consider variability in the source concentrations of saltstone. NRC staff agrees that the

ARP/MCU and SWPF waste streams are projected to have concentration less than 0.1 Ci/gal; however, DOE should evaluate the fraction of waste that may be above 0.1 Ci/gal.

Mat-reinforced epoxy-novolac thermosetting linings were recommended based on the assessment of experience with different lining materials, comparison of the materials to the design requirements, and recommendations from vendors, among other factors. The report recommends mat-reinforced epoxy-novolac thermosetting linings, but acknowledges that service life prediction is complex, long-term performance data are limited, and that performance is based on several assumptions that would require verification. These assumptions include: limited oxidation, gradual temperature decline, tolerable radiation dose with minimal dose rate effects, minimal differential settlement and proper installation. Numerous vendors were contacted by DOE for recommendations of coating systems given the design parameters. Throughout section 5.4 of the subject report is a discussion of lining degradation mechanisms and in particular dose rate effects. Processes that are rate-limited have the potential to not be identified in testing or from examination of performance data of a period of time that is shorter than the anticipated service life. In addition, the materials may exhibit cliff response where performance is relatively stable until a condition is achieved, where performance deteriorates relatively quickly. An example would be depletion of antioxidants in a polymer.

Teleconferences and Meetings

This report has not yet been discussed in a teleconference or meeting.

Open Issues

No open issues were identified as part of this review.

Conclusion

The NRC staff believes that this report was a sufficient assessment of lining systems that could be used to reduce the impact of sulfate attack on saltstone vault concrete. NRC staff concludes the primary vault lining requirements have been appropriately identified. The report adequately discussed lining degradation mechanisms, factors that could affect performance and key assumptions.

NRC staff would note that while the report did a good job of assessing different lining materials and evaluating their potential performance given the design goals and expected service environment, the actual performance of thermosetting lining materials would need to be verified for this particular application. If credit is taken for the thermosetting lining performance in the performance assessment the NRC staff recommends:

1) Performance of additional testing and research. The testing and research should consider how dose rate effects could be addressed.

2) Providing conceptual diagrams of the systems and conditions, including a description of how the system would avoid osmotic blistering and moisture vapor transmission.

3) Completion of the accelerated-aging test program noted in the report to validate conclusions and provide a model for lining service life prediction for this application.

4) Providing a more detailed description of the quality assurance (QA) processes, procedures, and controls for the lining systems selected for use in this application.

5) Evaluating the potential for waste to exceed 0.1 Ci/gal, and if necessary revise the lining assessment and selection process and associated testing.

References

WSRC. *Radiological Performance assessment for the Z-Area Saltstone Disposal Facility*, WSRC-RP-92-1360, Westinghouse Savannah River Company. 1992,

NRC FORM 335 (9-2004) NRCMD 3.7 U.S. NUCLEAR REGULATORY COMMISSION **BIBLIOGRAPHIC DATA SHEET** *(See instructions on the reverse)*	1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.) NUREG-1911, Revision 2
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Division of Waste Management and Environmental Protection
Office of Federal and State Materials and Environmental Management Programs
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

9. SPONSORING ORGANIZATION - NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*

Same as NRC address above

10. SUPPLEMENTARY NOTES

PROJ0734, PROJ0735, PROJ0736, and P00M-032

11. ABSTRACT *(200 words or less)*

This is the U.S. Nuclear Regulatory Commission (NRC) staff's report of its monitoring of U.S. Department of Energy (DOE) non-high-level waste disposal actions in calendar year 2009, in accordance with Section 3116(b) of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (the NDAA). Section 3116 of the NDAA requires that DOE consult with the NRC on its nonhigh-level waste determinations and plans and that the NRC, in coordination with the covered States of South Carolina and Idaho, monitor disposal actions that DOE takes to assess compliance with NRC regulations in Title 10 of the Code of Federal Regulations (10 CFR) Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," Subpart C, "Performance Objectives." The NRC has prepared this report in accordance with NUREG 1854, "NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations," issued August 2007 (NRC, 2007c).

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*	13. AVAILABILITY STATEMENT
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