Lessons Learned from an External Review of the Savannah River Site Saltstone Performance Assessment Program

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ABSTRACT

The Savannah River National Laboratory is actively working on a total revision of the Saltstone Performance Assessment. "Lessons Learned" from the review are being applied to this effort. Examples of the areas in which significant new work is being done are development of a methodology to do probabilistic uncertainty analyses, employing quantitative analytical tools to represent long-term chemical degradation of both concrete and the Saltstone wasteform, and then using those tools to come to a better understanding of how changes in the vault and Saltstone will affect the performance of the overall disposal system over long periods of time.

INTRODUCTION

Section 3116 of the 2005 Defense Authorization Bill required that the Tank Closure and the associated Salt Processing programs at the Savannah River Site be reviewed by the Nuclear Regulatory Commission. An integral part of this program is the performance assessment work on the Saltstone disposal facility. The original Saltstone Performance Assessment was completed in 1992. Since that time the processing and disposal facility has operated on an intermittent basis, and two small-scale performance assessment studies, called Special Analyses, have been completed. All three of these documents were reviewed by the Nuclear Regulatory Commission. One result of this external review process was the realization that there were a number of areas in the Savannah River Site performance assessment program that needed to be strengthened.

DISCUSSION

In February 2005 a document called a Waste Determination was submitted to the U. S. Nuclear Regulatory Commission (NRC) under a process defined in Section 3116 of the Ronald W. Reagan Defense Authorization Act of 2005. In May 2005 the NRC issued a Request for Additional Information (RAI). The responses were submitted to the NRC in July 2005. At the end of July, the NRC requested some further clarification, referred to as Action Items. There were also a number of public meetings at which the NRC reviewers asked questions and received replies. As part of the responses to the review questions a series of sensitivity studies were conducted to assess the effects of parameter uncertainty on the deterministic Saltstone Vault 4 Special Analysis.

A total of 33 sensitivity analyses have been performed for the all-pathways dose calculations to key radionuclides and model parameters for the Saltstone Vault 4 Special Analysis. The first sensitivity analysis was performed as the base case for the 2005 Special Analysis (SA). The sensitivity studies were performed using PORFLOW (ACRi, Inc. 2005) to quantify the impact of key model parameter settings on groundwater contaminant concentrations and dose at the 100-meter compliance well through 10,000 years. The use of the 100-meter compliance well, while consistent with NRC's licensing practices, is a very conservative point of compliance given the location of the facility in the General Separations Area and the long-term stewardship requirements for the site. These studies are summarized in Table I.

The key model parameters addressed in the sensitivity studies are:

- The values for initial and final saturated hydraulic conductivity of the vault concrete and Saltstone
- Precipitation and infiltration
- Distribution coefficients (K_d) and additional radionuclides
- Impact of flow through cracks
- Additional combinations of parameters

The new sensitivity scenarios are described below. Then, the results in terms of dose are discussed, followed by an analysis of the results and a discussion of the conclusions from the analyses.

A series of Saltstone Vault 4 sensitivity calculations were performed using PORFLOW (ACRI, Inc. 2005) to quantify the impact of key model parameter settings on groundwater contaminant concentrations and dose at the 100-meter compliance well through 10,000 years. PORFLOW is a software tool for multiphase fluid flow, heat and mass transfer in fractured porous media. Four radionuclides were chosen for this study: H-3, C-14, Se-79, and I-129; these radionuclides are the major contributors to dose from all pathways in the Vault 4 SA. The key model parameters addressed in this sensitivity analysis are:

Base Case (Nominal), Lower and Upper bounding infiltration through the upper geosynthetic clay liner (GCL) provided by Phifer [3]. The changes in infiltration rates through the upper GCL reflect three different land use scenarios which impact the effectiveness and longevity of the Vault 4 closure cap. The different infiltration rates also impact the hydraulic properties of the lower drainage layer and the vault base drainage layer due to transport and accumulation of silt in the drainage layers. Higher infiltration rate through the upper GCL results in higher transport rates of silt through the drainage layers and more rapid accumulation of silt.

Saturated hydraulic conductivities of the Saltstone waste form and the vault concrete. The saturated hydraulic conductivities were varied by an order of magnitude about the values used in the Saltstone Vault 4 Special Analysis (SA). The rates at which the hydraulic conductivities of the Saltstone and concrete increase over time were varied about the values used in the SA.

Relative permeability of the Saltstone waste form and the vault concrete. The relative permeability was set to unity.

Molecular diffusion coefficient of each species in the Saltstone waste form and vault concrete. The molecular diffusion coefficients were varied by an order of magnitude about the values used in the Saltstone Vault 4 SA.

Distribution coefficients of C-14, I-129 and Se-79. The distribution coefficients (K_d) were set to zero for these species in the vadose and aquifer transport simulations.

Chemical reducing property. The distribution coefficient (K_d) of Tc in both Saltstone and the vault was set to 1 (recommended value for oxidizing concrete) and 0 (pessimistic assumption) mL/g in the vadose zone portion of the simulations.

Table I summarizes each of the scenarios analyzed.

Table I. Description of Sensitivity Scenarios

Case	Description	Variables Altered	Discussion
1	2005 Special Analysis Base Case	N/A – Base Case	N/A – Base Case
2	Optimistic Cover Degradation	Peak Infiltration from 14 in/year to 7 in/year.	Addresses sensitivity of varying cap degradation
3	Pessimistic Cover Degradation	Peak Infiltration from 14 in/year to 21 in/year.	
4	Optimistic Vault Degradation	Saturated hydraulic conductivity of the vault goes from 1E-12 to 1E-10 cm/sec over 10,000 years.	Addresses sensitivity of varying vault degradation behavior
5	Pessimistic Vault Degradation	Saturated hydraulic conductivity of the vault goes from 1E-12 to 1E-8 cm/sec over 10,000 years.	
6	Optimistic Initial Vault Conductivity	Initial saturated hydraulic conductivity of the vault set at 1E-13 cm/sec	Addresses sensitivity of initial vault saturated hydraulic conductivity.
7	Pessimistic Initial Vault Conductivity	Initial saturated hydraulic conductivity of the vault set at 1E-11 cm/sec	
8	Optimistic Saltstone Grout Degradation	Saturated hydraulic conductivity of Saltstone grout goes from 1E-11 to 1E-10 cm/sec	Addresses sensitivity to Saltstone grout degradation rate
9	Pessimistic Saltstone Grout Degradation	Saturated hydraulic conductivity of Saltstone grout goes from 1E-11 to 1E-8 cm/sec over 10,000 years.	
10	Optimistic Initial Saltstone Grout Conductivity	Initial saturated hydraulic conductivity of Saltstone grout set at 1E-12 cm/sec	Addresses sensitivity to initial Saltstone grout saturated hydraulic conductivity

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Case	Description	Variables Altered	Discussion
11	Pessimistic Initial Saltstone Grout Conductivity	Initial saturated hydraulic conductivity of Saltstone grout set at 1E-10 cm/sec	
12	Pessimistic Cover Degradation and Pessimistic Vault and Saltstone Grout Degradation – Combination of Runs 3, 5 and 9	Peak Infiltration from 14 in/year to 21 in/year. Saturated hydraulic conductivity of the vault goes from 1E-12 to 1E-8 cm/sec over 10,000 years. Saturated hydraulic conductivity of Saltstone grout goes from 1E-11 to 1E-8 cm/sec over 10,000 years.	Addresses combined effect of pessimistic cover degradation, pessimistic vault and Saltstone grout conductivity.
13	Vault and Saltstone Grout Saturated for Entire Run	Relative hydraulic conductivity set to 1 for both the vault and Saltstone grout.	Addresses impact of saturation
14	Optimistic Vault Diffusion	Vault diffusion coefficient set to 1E-9 cm^2/sec	Assesses sensitivity to vault diffusion coefficient
15	Pessimistic Vault Diffusion	Vault diffusion coefficient set to 1E-7 cm^2/sec	
16	Optimistic Saltstone Grout Diffusion	Saltstone diffusion coefficient set to 5E-10 cm^2/sec	Assesses sensitivity to Saltstone diffusion coefficient
17	Pessimistic Saltstone Grout Diffusion	Saltstone grout diffusion coefficient set to 5E-8 cm^2/sec	
18	Pessimistic Vault and Saltstone Grout Diffusion – Combination of Cases 15 and 17	Vault diffusion coefficient set to 1E-7 cm^2/sec Saltstone grout diffusion coefficient set to 5E-8 cm^2/sec	Assesses sensitivity to combined vault and Saltstone grout diffusion coefficient
19	Pessimistic Partition Coefficients	Partition coefficients for C-14, Se-79 and I-129 set to 0 mL/g	Assesses sensitivity to K_d
20	Reducing Conditions in	Technetium Partition Coefficient set to 1000 mL/g.	N/A – Base Case for technetium

Table I. Description of Sensitivity Scenarios

Case	Description	Variables Altered	Discussion
	Vault at all times		
21	Oxidizing Conditions in Vault at all times	Technetium partition coefficient set to 1 mL/g.	Assesses sensitivity to redox state of vault and Saltstone grout
22	Oxidizing Conditions in Vault at all times with pessimistic technetium behavior	Technetium partition coefficient set to 0 mL/g.	Assesses sensitivity to redox state of vault and Saltstone grout, using pessimistic technetium partition coefficient.
23	Increase the final saturated hydraulic conductivity of degraded vault and Saltstone grout to 1E-6 cm/sec at 10,000 years	Concrete K_s increases from 10^{-12} to 10^{-6} cm/s with a degradation rate constant, α = 3 Saltstone grout K_s increases from 10^{-11} to 10^{-6} cm/s with a degradation rate constant, α = 2.5 Degradation Equation: $\log_{10}(k/k_o) = \alpha \log_{10}(t/t_o)$ where k = saturated hydraulic conductivity at time t, cm/s; k_o = saturated hydraulic conductivity at t_o = 100 years, cm/s Radionuclides Analyzed: H-3, C-14, Se-79, Tc-99, I-129 and Np-237.	A saturated hydraulic conductivity of 1E-6 cm/s is two orders of magnitude greater than the upper range of standard concrete (i.e., 1E-8 cm/s (Ramachandran and Beaudoin 2001)) and within the range of soil saturated hydraulic conductivities at SRS. Addresses more pessimistic values for saturated hydraulic conductivity of the vault and Saltstone grout final degraded state.
24	Increase precipitation and assess consequent increased infiltration.	Increase the average precipitation utilized within the base case (i.e., 48.9 in/yr) by 25%. Radionuclides Analyzed: H-3, C-14, Se-79, Tc-99, I-129 and Np-237.	In a publication of the U.S. Global Change Research Program (The Potential Consequences of Climate Variability and Change Overview Southeast (www.usgcrp.gov/usgcrp/Library/nationalassessment/overviewsoutheast.htm)), results from the two principal models used to assess climate change, due to CO_2 induced global warming, show increases in annual precipitation of no more than 25% across the Southeast U.S through year 2100. Further a report from the Intergovenrmental Panel on Climate Change (Climate Change 2001: Synthesis Report (www.ipcc.ch/pub/un/syreng/spm.pdf)), project that atmospheric CO_2 levels and hence, average temperature, will stabilize over the 22nd century. Addresses an increased average precipitation to explore the potential effect of climate change on the infiltration through the closure cap.
25	Combine increased	Sensitivity cases 5, 9, and 24 are combined. Cases 5 and 9 increase	A saturated hydraulic conductivity of 1E-8 cm/s is at the upper range of concrete saturated hydraulic

Table I. Description of Sensitivity Scenarios

Case	Description	Variables Altered	Discussion
	precipitation with pessimistic vault and Saltstone grout degradation	the final saturated hydraulic conductivity of the degraded vault and Saltstone grout at year 10,000 to 1E-8 cm/s. Case 24 increased the average precipitation by 25%. Radionuclides Analyzed: H-3, C-14, Se-79, Tc-99, I-129 and Np-237.	conductivity (Ramachandran and Beaudoin 2001). See case 24 for a discussion of the rationale for a 25% increase in average precipitation. Addresses the coupled effect of increased infiltration and increased degradation of the vault and Saltstone grout.
26	Decrease K_ds in all media by 10x and add additional radionuclides.	The K_ds for the radionuclides in all media are reduced by a factor of 10 from the values presented in Table A-8 of Cook et al. 2005. Radionuclides Analyzed: C-14, Se-79, Sr-90, Tc-99, I-129, Cs-137, U-238, Np-237, Pu-238 and Pu-239.	Additional strongly sorbed radionuclides have been added to the analysis. These radionuclides represent the most abundant, strongly sorbed radionuclides with both short and long half-lives and those with a high dose conversion factor. Addresses the impact of increased radionuclide mobility.
27	Combine pessimistic initial Saltstone grout conductivity and pessimistic Saltstone grout degradation.	Sensitivity cases 9 and 11 are combined. Saltstone grout K_s decreases from 10^{-10} to 10^{-7} cm/s with a degradation rate constant, α = 1.5 Degradation Equation: $\log_{10}(k/k_o) = \alpha \log_{10}(t/t_o)$ where k = saturated hydraulic conductivity at time t, cm/s; k_o = saturated hydraulic conductivity at t_o = 100 years, cm/s Radionuclides Analyzed: H-3, C-14, Se-79, Tc-99, I-129 and Np-237.	Addresses the coupled effect of a higher initial Saltstone grout saturated hydraulic conductivity and an increased Saltstone grout degradation rate.
28	Pessimistic initial vault saturated hydraulic conductivity of 1E-8 cm/s.	Concrete K_s decreases from 10^{-8} to 10^{-6} cm/s with a degradation rate constant, α = 1.0 Degradation Equation: $\log_{10}(k/k_o) = \alpha \log_{10}(t/t_o)$ where k = saturated hydraulic conductivity at time t, cm/s; k_o = saturated hydraulic conductivity at t_o = 100 years, cm/s Radionuclides Analyzed: H-3, C-14, Se-79, Tc-99, I-129 and Np-237.	A saturated hydraulic conductivity of 1E-8 cm/s is at the upper range of concrete saturated hydraulic conductivity. This assesses a higher initial vault saturated hydraulic conductivity.

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Case	Description	Variables Altered	Discussion
29	Simulate loss of reducing property in Saltstone grout and vault by reducing the K_d for those radionuclides affected by the change from reducing to oxidizing conditions.	The following two ends in the oxidation/reduction continuum in the Saltstone grout and vault are analyzed: Oxidizing K_ds for Tc-99 and the uranium isotopes taken from Bradbury and Sarott [4]. Reducing K_ds for Tc-99 and the uranium isotopes taken from Bradbury and Sarott [4]. Radionuclides analyzed: Tc-99 and U-238	Radionuclides whose K_ds are redox sensitive are considered. This includes the uranium isotopes (U-232, U-233, U-234, U-235, U-236, and U-238) in addition to Tc-99 (by agreement with the NRC, only U-238 was analyzed in addition to Tc-99). A response to an NRC Comment showed a 3 percent reduction in reducing potential after 10,000 years. A subsequent analysis showed a 5 percent reduction in reducing potential after 10,000 years with the presence of cracks due to seismic activity. This assesses both complete oxidation and complete reduction.
30	Combine oxidizing Saltstone grout & vault with increased infiltration and pessimistic vault and Saltstone grout degradation.	Sensitivity cases 25 and 29-oxidized are combined (increased degradation of the vault and Saltstone grout, increased infiltration, and oxidized condition of Saltstone grout and vault). Radionuclides Analyzed: Tc-99, U-238	See cases 25 and 29 for a discussion of the rationale. Addresses the combined effects of oxidized Saltstone grout and vault, increased infiltration, and increased degradation of the vault and Saltstone grout.
31	Assume saturation of the vault and Saltstone grout to assess flow through cracks.	Assume vault and Saltstone grout exhibit large-scale cracking at a 30 ft nominal spacing. Assume vault, Saltstone grout and cracks are fully saturated. Implemented by redefining the water retention and relative permeability curves, such that both are 1.0 regardless of suction head. Radionuclides Analyzed: H-3, C-14, Se-79, Tc-99, I-129 and Np-237.	The cracking is based upon modeling of potential impacts from large-scale seismic events and differential settlement. Cracks become active in the radionuclide transport process if they are completely water saturated. Addresses the effect of flow through cracks if the vault and Saltstone grout were to be saturated in the first 10,000 years.

Table I. Description of Sensitivity Scenarios

Case	Description	Variables Altered	Discussion
32	Assume saturation of the vault and Saltstone grout to assess flow through cracks with oxidizing conditions	Assume vault and Saltstone grout exhibit large-scale cracking at a 30 ft nominal spacing. Assume vault, Saltstone grout and cracks are fully saturated. Implemented by redefining the water retention and relative permeability curves, such that both are 1.0 regardless of suction head. Oxidizing K_ds used for Tc-99 Radionuclides Analyzed: : H-3, C-14, Se-79, Tc-99, I-129 and Np-237.	The cracking is based upon modeling of potential impacts from large-scale seismic events and differential settlement as documented. Cracks become active in the radionuclide transport process if they are completely water saturated. Addresses the effect of flow through cracks if the vault and Saltstone grout were to be saturated in the first 10,000 years in combination with oxidized conditions.
33	RAI# 19. Assumes greatly increased infiltration, hydraulic conductivity and diffusivity (vault and Saltstone grout), and oxidation.	Infiltration to the vault is 25 cm/yr throughout the simulation and the closure cap drains silted to allow infiltration to go to Saltstone grout. Hydraulic Conductivity of Vault and Saltstone Grout are set to 5E-7 cm/sec throughout the simulation. Effective diffusivity for the Vault and Saltstone Grout are increased by a factor of 10. Vault will be 1E-7 cm^2/sec (vs. 1E-8 in base case) and Saltstone Grout 5E-8cm^2/sec (vs. 5E-9 in base case). Modeled oxidation of Saltstone Grout as 0 and 100% and interpolated to get to 5-30% oxidation. Radionuclides Analyzed: Tc-99, Np-237, U-238, H-3, C-14, Se-79, and I-129.	The NRC requested this sensitivity case to consider a very degraded state throughout the simulation (closure cap, vault, Saltstone grout, oxidation) that combines a number of variables.

Sensitivity Results Expressed as Dose from All Pathways

The peak fractional concentrations from the PORFLOW model, and the revised inventory of radionuclides in Vault 4 were used to calculate peak radionuclide concentrations over 10,000 years. The peak concentrations were input to the LADTAP program [5] to calculate the all-pathways dose for each of the scenarios. The resulting doses are shown in Table II. The doses range from 0.0002 mSv/year for scenario 2 (decreased infiltration due to continuous bamboo cover) to 340 mSv/year for scenario 33 (oxidizing) (greatly increased infiltration, greatly increased vault and Saltstone grout hydraulic conductivity and diffusivity, and complete oxidation of the vault and Saltstone grout at time zero as if no slag was present). Only five of the

35 scenarios yield doses exceeding the performance measure of 0.25 mSv/year, despite the exaggerated assumptions of many of the scenarios.

Table II. Results of the Sensitivity Cases

Scenario	Variable	All Pathways Dose (mSv/yr)	Normalized Sensitivity (S_n)
1	Base Case	4.8E-04	
2	Infiltration, cm/yr	2.0E-04	1.2E+00
3	Infiltration, cm/yr	2.7E-03	9.3E+00
4	Vault Degradation Rate, cm/s-yr	3.1E-04	3.9E-01
5	Vault Degradation Rate, cm/s-yr	5.1E-04	6.9E-03
6	Vault Conductivity, cm/s	3.2E-04	3.7E-01
7	Vault Conductivity, cm/s	5.1E-04	6.9E-03
8	Saltstone Degradation Rate, cm/s-yr	3.7E-04	2.5E-01
9	Saltstone Degradation Rate, cm/s-yr	2.3E-03	4.2E-01
10	Saltstone Conductivity, cm/s	3.8E-04	2.3E-01
11	Saltstone Conductivity, cm/s	2.4E-03	4.4E-01
12	Cases 3+5+9, cm/yr	4.0E-02	1.6E+02
13	Relative Permeability	1.8E-03	
14	Vault Diffusivity, cm^2/s	3.5E-04	3.0E-01
15	Vault Diffusivity, cm^2/s	1.7E-03	2.8E-01
16	Saltstone Diffusivity, cm^2/s	3.9E-04	2.1E-01
17	Saltstone Diffusivity, cm^2/s	6.4E-04	3.7E-02
18	Cases 15 + 17, cm^2/s	6.8E-03	1.5E+00
19	All Kds = 0 mL/g	3.6E-01	
20	Tc Kd = 1000, mL/g	1.6E-15	
21	Tc Kd = 1, mL/g	3.2E-02	-6.7E+01
22	Tc Kd = 0, mL/g	9.0E-01	-1.9E+03
23	Vault and Saltstone degrade to 1E-6, cm/s-yr	1.6E-01	3.3E-01
24	Infiltration +25%, cm/yr	1.1E-02	8.8E+01
25	Cases 5+9+24	6.6E-02	5.5E+02
26	Kds -10x	1.8E-02	
27	Cases 9+11	4.3E-03	8.8E-01
28	Saltstone K0 = 1E-8, cm/s	1.1E-03	1.3E-03
29 Ox	Tc Kd = 1, U Kd = 2000, mL/g	3.2E-02	-2.0E+02
29 Red	Tc Kd = 1000, U Kd = 5000, mL/g	1.6E-15	-1.0E+00
30	Cases 25 + 29 Ox	1.2E+01	-7.6E+04
31	Saturated Cracks	3.5E-02	
32	Saturated Cracks + Ox	2.6E-01	
33 Ox	Cases 24+18+29+silted drains+ vault and Saltstone	3.4E+02	-7.1E+05
33 Red	Ksat=5E-7 cm/s	3.1E+00	2.1E+03

Analysis of Sensitivity Results

To assist in interpreting the results of the sensitivity study, a measure called the normalized sensitivity [6] was used. Equation 3-2 of this reference is:

$$S_n = \frac{x_a}{D_a} \cdot \frac{\delta D}{\delta x} \qquad \text{(Eq. 1)}$$

S_n is the normalized sensitivity, x_a and D_a are the nominal values of the parameter in question and the peak dose and δ D and δ x are the changes in dose and the parameter, respectively, in each sensitivity case. Using the normalized sensitivity measure eliminates the effects of units and the absolute magnitude of each parameter. The absolute value of S_n is a measure of the importance of the parameter or parameters to the calculated dose for each case (i.e., the parameters being most important to calculated dose).

Table II gives the results and the value of S_n for each of the sensitivity cases. Cases 13, 19, 26, 31 and 32 evaluated a fundamentally different approach than that used in the 2005 Special Analysis (e.g., relative permeability always set to 1, all partition coefficients set to zero mL/g), and thus could not be evaluated using this approach.

The cases having the five greatest absolute values for the normalized sensitivity are 33-Oxidizing (-710,000), 30 (-76,000), 33-Reducing (2100), 22 (-1900) and 25 (550). Of these five case, four (33-Oxidizing, 30, 33-Reducing and 25) involve an increase in precipitation or infiltration and three (33-Oxidizing, 30 and 22) involve the lack of reducing capacity in the disposal system, which is characterized by a low value of the partition coefficient for technetium. The five cases involving a change in only one parameter with the greatest normalized sensitivity are 22 (-1900), 24 (88), 21 (67), 3 (9.3) and 2 (1.2). Each of these deals either with infiltration or the partition coefficient of technetium.

The conclusion of this analysis is that the calculated dose from the Saltstone disposal system is most sensitive to the oxidation state of the system, which determines the partition coefficient for technetium, and the amount of precipitation, which determines the infiltration rate of water reaching the disposal system. The actual state of the system with respect to these parameters is determined by the design and implementation of the final cover and the materials used to construct the disposal vault and prepare the Saltstone waste form.

The study shows that the calculated dose is far less sensitive to the values used for initial saturated hydraulic conductivity of the vault and Saltstone grout, and the degradation rates of those materials than to precipitation and oxidation state.

Determination of the Path Forward

At the conclusion of the NRC review, the technical team that has worked on the Saltstone PA and the responses to the NRC met to come up with a list of research item that could be undertaken to improve the PA process. The items discussed comprised 10 general categories: Performance Assessment Philosophy, Vault and Saltstone Degradation, Performance Assessment Assumptions, Use of Outside Information Sources, Sensitivity/Uncertainty Analysis, Additional Data Needs, Model Validation, Individual Models Used in the PA Process, Closure System Issues and Field and Operational Practices.

After each category was identified, the attendees presented ideas which, if implemented, could make the upcoming PA projects better products. Each item was categorized as to whether or not it was included within the scope of work for FY ’06. Those items determined to not be currently funded were categorized as Research and Development items.

The Research and Development items were prioritized by the meeting attendees by giving two points to the six items each attendee thought were the most significant and one point to the six next most important. The attendee most familiar with each item was asked to provide a rough cost estimate and duration for implementing that item.

Meeting Results

The results of the prioritization process are shown in Table III. The Research and Development items are given along with the total score from the attendee poll.

Table III. Ranking of Top Ten Research and Development Items

Rank	Maintenance Item	Ranking Score
1	Experimental determination of degradation rates of Saltstone, concrete and tank fill material	18
2	Plugging of drainage layers - Literature and field studies	16
3	Characteristic curves for cementitious materials	14
4	Saltstone, concrete and grout - lab and production samples for archive	14
5	External review and interaction during PA process	12
6	Saltstone, concrete and grout lab and production samples for testing	12
7	Saltstone pore water chemistry	11
8	Technetium solubility in Saltstone pore fluid	10
9	Develop in-house expertise in probabilistic uncertainty analysis	9
10	Samples from lysimeters - Determination of leachate-soil interactions	9

As a result of the comprehensive review by the NRC staff and the SRNL analysis of the process, we now have active programs in place to:

Compile all available hydraulic data on subsurface materials, waste forms and disposal unit construction materials from our disposal facilities, Compile all available chemical data on subsurface materials, waste forms and disposal unit construction materials from our disposal facilities,

Develop in house expertise in performing probabilistic uncertainty analyses,

Develop an understanding of the fundamental physical and chemical degradation processes that will occur in concrete and Saltstone and how to represent these processes in the PA models,

Verify model calculations against existing field experiments.

CONCLUSION

A number of potential improvements to the SRS PA program have been identified. Many of these will be incorporated into the next generation of performance assessments that will be completed in FY '06 as a part of their current scope. There are other items that require additional funding and resources to complete. A prioritized listing of these is given. It is possible that the NRC will request additional research and development work as part of their Technical Evaluation Report on the Salt Waste Determination document. Once that report is issued, discussions will be held with the Closure Business Unit customer to determine which research and development programs will be funded.

A mature PA program includes an ongoing research and development program. Waste Management Area Project (WMAP) has such a program and every year a significant amount of funding ($478K in FY 06) is identified for studies to improve the PA program.

The results of this comprehensive analysis will be used to support improvements to the PORFLOW model to allow simulation of the changing oxidation-reduction condition of the waste disposal system over time And obtaining additional data on hydraulic properties of the system. The necessary data and model improvements will be accomplished as elements of Performance Assessment (PA) maintenance and the results incorporated into future performance assessment work.

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