October 29, 2010

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

FROM: Nishka Devaser, Project Manager **/RA/**
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SUBJECT: SEPTEMBER 2, 2010, MEETING SUMMARY: MEETING TO DISCUSS REQUEST FOR ADDITIONAL INFORMATION RESPONSES FOR REVIEW OF THE UPDATED PERFORMANCE ASSESSMENT FOR THE SALTSTONE DISPOSAL FACILITY

On September 2, 2010, the U.S. Nuclear Regulatory Commission (NRC) staff met with the U.S. Department of Energy (DOE) by telephone to discuss the DOE's response to the NRC's Request for Additional Information (RAI) pertaining to the review of the 2009 Performance Assessment (PA) of the Saltstone Disposal Facility. The meeting was open to the public via teleconference.

The purpose of the meeting was for the NRC and DOE to engage in a technical exchange concerning DOE's responses to the RAI. The comments and their respective responses discussed are available on the NRC's Agencywide Documents Access and Management System (ADAMS), which provides text and image files of NRC's public documents. The accession number for the comments (NRC's RAI) is ML100820097 and the response is ML102090658. It was decided prior to and was stated in this meeting, that the NRC will issue an additional information request so that concerns discussed during the meeting can be properly addressed in the staff's review of the Saltstone PA.

A summary of the discussion and list of attendees can be found in the enclosures, respectively.

Enclosures:
1. Meeting Summary
2. Meeting Attendees

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ML102980289

OFC	DWMEP:PM	DWMEP:LA	DWMEP:BC	DWMEP:BC	DWMEP:PM
NAME	NDevaser	AWalkerSmith	CMcKenney	GSuber	NDevaser
DATE	10/25 /10	10/26/10	10/28/10	10/28/10	10/29/10

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Summary of Meeting: Meeting to Discuss Request for Additional Information Responses for Review of the Updated Performance Assessment for the Saltstone Disposal Facility

The first topic discussed during this meeting was the expected degradation case (or the base case) considered by DOE in the Saltstone PA.

NRC staff requests a revised base case:

NRC staff stated that the use of one-off analyses for performing sensitivity analyses of the deterministic base case can be problematic. Such an approach is appropriate in certain cases where there are only a few issues to be addressed with one-off analyses and where there is a lot of margin between the expected doses and the compliance criteria. This approach does not work well when there are numerous significant issues to address or when the relative changes observed in the analyses are significant. DOE stated that the values used in the one-off analyses (i.e. an analysis where one parameter is varied while the remainder of the parameters is constant) were set to conservative extremes. NRC then stated that using extreme values in a system with multiple unknowns may lead to some ambiguity about what the expected case is. DOE requested a list of specific parameters that the NRC would like to be reevaluated and included in the base case (i.e. compliance case) model representation. The NRC staff stated that a list had been prepared and agreed that the list would be helpful and offered to go through the list at the end of the meeting. The NRC also stated that this list may not be all-inclusive. DOE should establish a base case (parameters and conceptual models) that has adequate technical basis and appropriately reflects uncertainties. NRC staff also requested that DOE list the optimisms, pessimisms, and uncertainty in each of the later stated parameters.

List of Base Case considerations:

- Time-variant properties of saltstone e.g., hydraulic conductivity, effective diffusion coefficient (behind the sulfate front)
- Hydraulic conductivity uncertainty of intact saltstone that accounts for spatial scaling, variation in composition, emplacement conditions, etc.
- Cracking of saltstone and vaults that represent current as well as future potential cracking
- Alternative degradation scenarios for disposal unit concrete
- Moisture characteristic curves for intact and cracked saltstone and vaults that are consistent with the literature, conservatively estimated, or bounding (relative permeability = 1)
- Uncertainty with respect to the Eh and pH transitions
- Uncertainty in the long-term performance of geotextile filter fabrics
- Performance of the vaults in light of observations
- Variability in the transfer factors
- Consumption of poultry and eggs
- Radionuclide build-up in irrigated soils
- Inventory uncertainty
- Evaluation of strongly sorbing and short-lived radionuclides (e.g., Sr-90) at 1 m

Specific Comment Discussions:

This section describes each comment discussed at the meeting and places it beside the referenced comment and respective response. Please note that the following comments are provided as a summary of the complete version of each comment and response available on the NRC's Agencywide Documents Access and Management System (ADAMS), which provides text and image files of NRC's public documents. The accession number for the NRC comments (NRC's RAI) is ML100820097 and DOE's response is ML102090658.

Comments PA-3, PA-4, and PA-5

The discussions of PA-3, PA-4, and PA-5 were merged because of similarities between comments and concerns.

PA-3 The determination of key radionuclides described in Section 5.2.2 of the PA may not have captured all of the risk significant radionuclides.
PA-4 Benchmarking based only on key radionuclides identified in the base-case analysis does not provide adequate support for interpretation of alternate-case GoldSim model results.
PA-5 Additional information is needed about the benchmarking factors and other GoldSim parameter adjustments.

Discussion

NRC and DOE staff discussed the process used for benchmarking the GoldSim model. NRC staff expressed concern that the GoldSim model may not be applicable to radionuclides other than those that it was benchmarked for. Because moderate to significant (in magnitude) benchmarking factors were needed to achieve agreement between the PORFLOW and GoldSim results, NRC stated they did not have confidence that the GoldSim model results for radionuclides that were not subject to benchmarking were reasonable. NRC believed one way to test this would be to perform additional PORFLOW simulations for radionuclides that previously were not subject to the benchmarking exercise and check the agreement with the GoldSim model results. In computational modeling, this may be termed a validation test case. In addition, the PORFLOW calculations were not performed for all radionuclides for all of the cases, so it is not possible to compare the two models to confirm that the GoldSim model is accurately calculating the transport for all radionuclides. DOE stated they had confidence in the additional (non-benchmarked) results because the adjustments made were solely to account for differences in the flow representations between GoldSim and PORFLOW. NRC stated they did not have this confidence without additional comparisons, such as the blind comparisons described above.

Comment SP-1

Additional justification is required for the assumption that saltstone is hydraulically undegraded for 20,000 years.

Discussion

This ongoing research is of high quality and of high importance. However, NRC staff believes it is optimistic to assume no hydraulic degradation over 20,000 years when (i) the immersion tests were conducted for 31 days (relevant degradation processes were not necessarily included and these processes would not be expected to be observed in 31 days), (ii) determination of hydraulic properties of leached saltstone are yet to be conducted, and (iii) there is limited model support for the long-term performance.

The effects of degradation are evaluated in sensitivity cases, but the conservatism of these cases is unclear. NRC noted the analysis provided focused on sulfate attack, but NRC was interested in a basis for degradation (or lack thereof) of all relevant degradation mechanisms. The example was provided of reinforcement corrosion. The disposal facilities, especially the older vault designs, have a fair amount of embedded steel some of which is exposed to the atmosphere or will be exposed to the soil after facility closure. It is unrealistically optimistic to expect that steel will not experience corrosion and cause disruption of the surrounding concrete. DOE understood the concern that all relevant degradation mechanisms should be covered and adequate model support is needed.

Comment SP-2

A basis is required for the modeled extent of saltstone fracturing.

Discussion

It is not clear that the impact of cracking on the PA results is adequately captured by Case C, sensitivity analyses that address increased hydraulic conductivity, or alternate configurations such as Case E. The provided references (T-CLC-Z-00006; SRNL-STI-2009-00115 Rev 1) address cracking mechanisms for Vault 4 due to differential settlement and seismic events. Case C is intended to capture the impact of transverse structural cracks through saltstone caused by these mechanisms. However, a basis is not provided to extend the mechanisms responsible for Vault 4 cracking to saltstone and address fracture mechanisms that are unique to saltstone. Cracking of saltstone has been observed (SRNL-ESB-2008-00017) and the uncertainty and variability in (i) cracking (e.g., number of cracks, crack spacing, crack orientation, crack length, crack aperture, etc) and (ii) crack evolution (e.g., acceleration of cracking) has not been evaluated. Therefore, it is not clear that two longitudinal cracks capture the range or effects of potential cracking.

Sensitivity analyses with increased hydraulic conductivity do not evaluate the full matrix of the potential effects of cracks. For example, changes to the surface-area-to-volume ratio, which is dependent on crack representation, is not captured by varying the hydraulic conductivity. Removal of radionuclides and leaching of cementitious materials, which can lead to additional fracturing, is strongly correlated to the surface-area-to-volume ratio.

In addition, results from sensitivity analyses with increased hydraulic conductivity and Case E are inconclusive due to the moisture characteristic curves applied in the PA (see Comments SP-3 and SP-4).

DOE believed that the synergistic sensitivity analysis cases were conservative and sufficiently captured the extent of fracturing. However, DOE also understood the previous NRC concern with addressing uncertainties via one-off sensitivity cases such that the uncertainty was not reflected in the expected (or compliance) case.

Comment SP-3

The moisture characteristic curve for intact saltstone implemented in the PORFLOW model does not sufficiently account for experimental uncertainties and is inconsistent with literature results for material similar to saltstone and other cementitious materials.

Discussion

Rerunning the Base Case with a constant relative permeability of 1.0 is a bounding approach to evaluate the influence of these curves. However, a larger issue is that the Base Case and evaluations of single parameter adjustments are ambiguous when a significant number of uncertainties are not accounted for in that case.

Increases in dose of 10%, 30%, 100%, etc for one-off sensitivity analyses may result in a insignificant increase in base case dose on an absolute basis (i.e. if the base case dose is small). However, when (i) many uncertainties exist, (ii) the margin between compliance and the base case dose is not very large, and (iii) it is not clear how all of these uncertainties are related, then the resultant dose from the inclusion of these outstanding uncertainties could be significant on a cumulative basis even if the increases for individual one-off analyses are insignificant on a absolute basis.

DOE believed that using a constant relative permeability of 1.0 was the most conservative selection to evaluate the importance of the issue. However, DOE also understood the previous NRC concern with addressing uncertainties via one-off sensitivity cases such that the uncertainty was not reflected in the expected (or compliance) case.

Comment SP-4

Characteristic curves implemented in the PA are based on a continuum approach that does not reflect non-equilibrium flow.

Discussion

This RAI was attempting to address flow, not solubility. Gravity driven, transient flow is the norm in the laboratory or field. Understandably, abstraction of fracture flow is complicated. However, a continuum approach is incapable of capturing the highly non-linear response of transient flow. Model support (e.g., analogs, laboratory experiments, and/or field studies) is necessary to support the level of credit that is taken in the PA. NRC noted that in DOE's models a decrease in saturation from 100% to 99.25% resulted in a 9 order of magnitude reduction in flow. DOE understood the concern expressed by NRC.

Comment SP-5

Additional support is needed for the hydraulic conductivity of intact saltstone that is used in Case A, Case B, Case C, Case D and the synergistic case.

Discussion

Ongoing tests are helpful and fill some important data gaps, but they still do not capture the full range of conditions that can be expected for actual emplaced saltstone. NRC discussed that as additional measurements have been collected the hydraulic property values have been consistently revised higher. These hydraulic tests are on laboratory prepared samples which do not account for: (i) scale, (ii) emplacement (batching, pumping, curing), (iii) CO_2 contamination, and (iv) permeability evolution. The PA relies on sensitivity analyses to evaluate the impact of higher hydraulic conductivity due to its uncertainty. However, a one-off sensitivity case does not provide adequate insight.

DOE stated that the PA reflects their current understanding of saltstone properties, and that research is ongoing to address the uncertainties noted by NRC.

Comment SP-6

Additional basis is required for the values of the effective diffusivity of intact and degraded saltstone used in the base case and sensitivity cases.

Discussion

NRC discussed that the RAI response took the approach of estimating the Peclet number, or the relative magnitude of advection and diffusion. However the Peclet number uses the diffusion coefficient itself. The analyses provided by DOE presented when diffusion may be important relative to advection, but not if diffusion is important relative to advection. NRC stated that an adequate technical basis for the effective diffusivities used in the base case (e.g. measurements that reflect key uncertainties) was needed. DOE stated that they understood the concern.

Comment SP-7

Additional bases are needed for key assumptions used in the simulation of sulfate attack with the STADIUM code.

Discussion

NRC discussed that some assumptions in the sulfate attack analyses need additional technical basis. NRC stated that the initial mineralogy can have a significant effect on the estimated degradation times, because it affects the reaction paths of the simulations. Research completed by Sohini Sarkar as part of the Cement Barriers Partnership showed how sensitive the results could be to initial mineralogy. The method described by Sampson and Marchand has not been demonstrated for tertiary blends. NRC also discussed the concern about minor species. DOE stated in the sulfate attack analyses report that it was assumed that minor

species could be neglected, and in the RAI response discussed electro-diffusion. However, NRC indicated that their concern was not limited to electro-diffusion, but rather how does one know whether the minor species can be neglected without testing the hypothesis numerically or experimentally. DOE stated that they understood NRC's concern about the effect of initial mineralogy on correctly determining the mineral phases that are represented and that they will review the bases given for the different degradation cases.

Comment SP-8

The initial grout mineralogy used in evaluating expansive phase precipitation is inconsistent with the initial mineralogy used to determine Eh and pH transitions in pore fluids.

Discussion

NRC staff stated that DOE should ensure that uncertainty about the expected amount of saltstone degradation (as assumed from the expansive phase report) is reflected in the base case. The research described in the expansive phase report is preliminary research, so it is expected that there could be a high degree of uncertainty associated with this research. The use of this research without considering this uncertainty may not be sufficiently conservative.

Comment SP-12

Model support is needed for the process models supporting PA predictions of Eh–pH evolution for cementitious materials.

Discussion

The NRC recognizes that additional work will be done to provide model support, however, stating that a lack of model support was accounted for by the uncertainty analysis is generally insufficient unless:

(i). Justification is provided to show that the range of parameter values considered in the uncertainty analysis encompasses the uncertainty in the model;
(ii). The uncertainty and sensitivity analyses are reasonably conservative; and
(iii). The impact of the uncertainty is limited locally and globally in the analysis.

DOE understood the need for adequate model support, and stated they would assess an appropriate path forward.

Comment SP-13

The effect of limiting the shrinking-core model to the effects of the Eh evolution of saltstone on Tc should be analyzed.

Discussion

NRC stated that the comparisons provided in the RAI response are useful but part of the point of the RAI was that other radionuclides could have been larger contributors to dose if the release were modeled differently. Analyzing the effect only for the radionuclides that caused a certain dose in the base case misses the point that the way the release was modeled could be affecting which radionuclides appear to be the most significant dose contributors. DOE understood the concern.

Comment SP-15

The basis for the adopted technetium pseudo-Kd of 1,000 mL/g for reducing conditions for Tc is not clear.

Discussion

NRC staff stated that they did not believe that a basis was provided for the use of a high value for Tc sorption on reducing grout. In addition, experimental results that showed that Tc did not sorb onto reducing grout did not seem to have been considered. NRC staff also noted that the 5,000 mL/g value used as the recommended K_d was based on experiments in which sodium dithionite was used as a reducing agent. Because saltstone does not contain sodium dithionite, it is not clear that this K_d value is applicable.

NRC staff also asked for clarification on whether the K_d value used in the shrinking core model was 1,000 mL/g or 5,000 mL/g. DOE stated that the specific K_d value for Tc-99 in the shrinking core model (i.e., 1000 or 5000 mL/g) was unimportant as it was implemented as a starting point where Tc-99 is essentially immobilized. The use of 1000 mL/g versus 5000 mL/g does not change the results. DOE also stated that they will review the basis for the Tc-99 K_d of 5,000 mL/g by comparing saltstone and vault materials to study samples.

Comment II-1

Key assumptions about the potential pathways of exposure of an inadvertent intruder appear to underestimate dose.

Discussion

NRC and DOE staff discussed several aspects of the intruder analysis calculations.

NRC staff asked about whether the PORFLOW calculations average the concentration over the grid spacing. This could result in the concentration at 1 m being diluted over a larger area. This could be problematic for radionuclides that decay fairly quickly and are transported slowly (e.g., Sr-90) because the concentration at 1 m might be much higher than the concentration further out. DOE staff stated that all PORFLOW calculations involved averaging over the grid spacing.

NRC staff also asked if an analysis of the dose based on the concentration under the FDC was performed similar to the analysis done for Vault 4.

NRC staff also asked if the Darcy velocity used in the Vault 4 calculation was the Darcy velocity upgradient or downgradient of the vault. DOE staff stated that they would look into the answer to this question. As discussed in more detail in other RAI discussions, NRC staff also has concerns about the exclusion of the chicken and egg pathway and the factors used to calculate buildup. NRC staff also stated that they would like to see the calculated dose for the individual radionuclides for the intruder calculations.

Comment II-2

The basis for the use of Case A to calculate the intruder dose is not provided. Additionally, the methodology used for determining the key radionuclides for the intruder uncertainty/sensitivity analysis may have resulted in radionuclides that are risk significant to the intruder being excluded from this analysis.

Discussion

NRC staff stated that it does not believe that Case A represents the reasonably expected degradation state, and therefore, the NRC staff does not believe that this is the appropriate case to use for the intruder scenario.

NRC staff also stated that it is not convinced that all radionuclides that are risk significant for the intruder scenario were included in the intruder uncertainty/sensitivity analysis. In the uncertainty analysis performed using GoldSim, the concentrations at 1 m were estimated by multiplying the 100 m concentrations by 1.6 (i.e., the maximum ratio of the 1 m to 100 m concentrations observed for the key radionuclides). However, NRC staff believes that this approach might underestimate the intruder dose from radionuclides that are transported slowly and decay fairly quickly (e.g., Sr-90) because these radionuclides might decay before they get to 100 m. The ratio of the 100 m to 1 m concentrations for these radionuclides might therefore be much higher than 1.6.

DOE Response to Discussion

DOE stated that they would review the methodology used for determining key radionuclides and get back to the NRC.

Comment B-1

The basis for excluding biotic transfer factors from the uncertainty analysis is unclear.

Discussion

NRC discussed that biotic transfer factors directly influence calculated doses and can have very broad ranges. In many instances, the DOE recommended values are equal to the minimum value of the distribution. It wasn't clear to NRC why the expected value in the base case would be an end point of the uncertainty distributions. Appropriate ranges of values need to be selected and there is no basis to not include the biotic transfer factors in the uncertainty analysis unless the contribution of the pathway to dose is demonstratively small. NRC noted because uncertainty in biotic transfer factors are large and data can be limited that conservative

selections are needed. DOE stated that section 4.6 of the 2009 Saltstone PA provided the values used for the deterministic base case, and the basis (references) supporting their selection. In most cases, DOE believed that conservative selections had been made. NRC stated they would reexamine the supporting information and may have additional questions.

Comment B-2

A basis for excluding the other animal product pathways (e.g., consumption of poultry and eggs) from the dose assessment is not provided.

Discussion

The DOE response indicated that chickens do not consume local feed; therefore the pathway was not included in the assessment. NRC staff noted that the RAI response does not address the fact that even if the chickens consume clean feed from off-site, the chickens would still likely drink water from on-site. In addition, NRC staff stated that the basis for the source of the chicken's feed was a single personal communication reference and that chickens can also consume local materials such as grass and insects from the site. NRC staff believes that the dose assessment should include the dose contribution from chickens consuming site groundwater and consuming some fraction of food from onsite.

DOE staff stated that they performed a calculation to determine the additional dose due to chickens consuming contaminated water and the results indicated that this dose was not significant.

Comment B-3

The effects of radionuclide build-up in irrigated soils may be underestimated.

Discussion

The DOE analysis in the RAI response shows very large relative changes (small absolute). As previously discussed, NRC staff stated in the meeting that a large relative change cannot be neglected unless it can be shown that all items addressed with one-off analysis have a small cumulative impact, or in a case like this, show that the doses are insignificant under all scenarios/pathways including alternative cases. It was noted by NRC staff that radionuclide buildup may be significant in some scenarios but not others. DOE staff understood the concern and how it fit into the more generic issue regarding use of one-off analysis.

Comment IN-1

The reported inventory of some of the radionuclides disposed of in Vaults 1 and 4 as of March 31, 2009 (X-CLC-Z-00027) exceeds the total inventory of these radionuclides assumed in the PA.

Discussion

NRC staff asked what changed since the X-CLC-Z-00027 document was published that caused the inventories of these radionuclides to be recalculated. NRC staff was under the impression

that the inventory of all the radionuclides was already recalculated in the analysis described in X-CLC-Z-00027. However, DOE staff stated that the X-CLC-Z-00027 document only included a recalculation for certain radionuclides and the inventory of these radionuclides was not recalculated in that analysis.

In addition, staff requested an explanation of how the Th-230 inventory was derived since the progeny of this radionuclide, Ra-226, is a key radionuclide in this analysis. NRC staff was interested in understanding what caused the inventory of this radionuclide to be higher in this analysis than in the 2005 PA. DOE stated they would review these concerns and get back to the NRC.

Comment IN-3

Information is needed on the process that will be used to ensure that the inventory will be distributed among the Future Disposal Cells (FDCs) in a configuration that provides reasonable assurance that the performance objectives will be met.

Discussion

NRC staff noted that the deterministic compliance case in the PA assumed that the inventory in each individual FDC was equal to the average inventory. NRC staff noted that without an evaluation of the dose consequence when individual FDC inventories exceed the average, NRC staff will have to monitor to the inventory assumed in the compliance case. If the NRC monitors each FDC to the average inventory, it is likely that there will be numerous open issues created on this topic. NRC staff noted that it may be easier to have an evaluation of the dose consequence created ahead of time rather than to address this with numerous open issues.

Comment IN-4

More information is needed about the inventory expected to remain in the sheet drain systems for Vault 4 and the FDCs and the inventory expected to remain in the transfer lines at the time of closure.

Discussion

NRC staff stated that the basis for the assumption that the amount of inventory in the sheet drain system will be negligible is unclear. NRC staff also asked if it was possible to bound the maximum inventory that could remain in these systems.

DOE stated that they previously indicated that the bleed water system would be flushed prior to facility closure, and that they could provide the NRC with the volume of material expected to remain in the bleed water system.

Comment VP-1

Additional analysis is needed to assess the applicability of the degradation mechanisms responsible for the observed fracturing of Vault 1 and 4 walls and the degradation mechanisms described in SRS-REG-2007-00041 to the FDCs and to other parts of Vaults 1 and 4.

Discussion

NRC stated that the PA and associated models should represent fractures and degradation of the FDC's including the impact on fluid flow consistent with the observations of Vaults 1 and 4 and the newly constructed FDC's. In summary, the PA should reflect the known conditions of the various systems. The PA models need to adequately reflect the mechanisms of observed flow and transport. DOE stated that they agreed the PA should reflect the known conditions and that they had attempted to do that.

Comment VP-2

Additional basis is required for neglecting disposal unit degradation mechanisms other than sulfate attack.

Discussion

NRC indicated that the response was mostly complete, but that the approach relied upon a sensitivity case. This was another case where the issues or uncertainties, as necessary, should be reflected in the base case not in an alternative analysis case. NRC noted that the DOE RAI response did not address corrosion cracking, or the request for information on similar systems that would provide analog information as technical basis (e.g. model support). DOE understood the concern expressed by NRC.

Meeting Attendees

George Alexander	U.S. Nuclear Regulatory Commission
Nishka Devaser	U.S. Nuclear Regulatory Commission
David Esh	U.S. Nuclear Regulatory Commission
Christepher McKenney	U.S. Nuclear Regulatory Commission
Karen Pinkston	U.S. Nuclear Regulatory Commission
Gregory Suber	U.S. Nuclear Regulatory Commission
John McCain	South Carolina Department of Health and Environmental Control
Chun Pang	U.S. Department of Energy
Patricia Suggs	U.S. Department of Energy
Linda Suttora	U.S. Department of Energy
Tom Robinson	Savannah River Remediation
Kent Rosenberger	Savannah River Remediation
F. Malcolm Smith	Savannah River Remediation
Steve Thomas	Savannah River Remediation
Richard Shepherd	Savannah River Remediation