SRR-CWDA-2011-00044
Revision 0

Comment Response Matrix
for
Nuclear Regulatory Commission RAI-2009-02
Second Request for Additional Information (RAI) on the Saltstone Disposal Facility Performance Assessment (SRR-CWDA-2009-00017, Revision 0, dated October 29, 2009)

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ACRONYM / ABREVIATIONS

DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FTF	F-Area Tank Farm
GCL	Geosynthetic Clay Liner
GSA	General Separations Area
HDPE	High Density Polyethylene
HELP	Hydrologic Evaluation of Landfill Performance Model
IAEA	International Atomic Energy Agency
LW	Liquid Waste
MOP	Member of the Public
MSL	Mean Sea Level
NRC	U.S. Nuclear Regulatory Commission
PA	Performance Assessment
PNNL	Pacific Northwest National Laboratory
QA/QC	Quality Assurance/Quality Control
RAI	Request for Additional Information
SA	Special Analysis
SCDHEC	South Carolina Department of Health and Environmental Control
SDF	Saltstone Disposal Facility
SPF	Saltstone Production Facility
SRS	Savannah River Site
TER	Technical Evaluation Report

Executive Summary

This document represents the first of two packages of responses to the comments transmitted via the *Second Request for Additional Information for the 2009 Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site,* dated December 15, 2010. [ML103400571]

Responses to this second round of U.S. Nuclear Regulatory Commission (NRC) Requests for Additional Information (RAIs) are being submitted in two packages. This first package, SRR-CWDA-2011-00044, Revision 0, responds to those RAIs that could be answered in a timely manner without significant research or additional computer modeling. The second submittal, SRR-CWDA-2011-00044, Revision 1, will include responses to the remaining RAIs and will consolidate the responses to all of the NRC December 15, 2010 comments.

This first package includes the responses to the following RAIs:

PA-6	IN-5	SP-14	VP-5	FFT-1	B-1	C-8
PA-12	IN-6	SP-15		FFT-2	B-2	C-22
PA-13		SP-18			B-3	C-23
					B-4	
					B-5	

The responses to a number of RAIs within the second package require further computer modeling to fully respond to the RAIs. A meeting with the NRC is anticipated in late April to discuss the model development approaches and the parameters proposed to ensure that the new modeling case(s) sufficiently address the NRC comments.

Performance Assessment Methods (PA)

PA-1	**Comment:** The contribution of individual radionuclides to the dose was not provided for several deterministic sensitivity cases. **NRC Response:** The answer to this RAI was adequate. **Path Forward:** N/A
Response PA-1: N/A	

PA-2	**Comment:** Probabilistic sensitivity analyses were not provided for cases representing bulk saltstone degradation. **NRC Response:** The answer to this RAI was adequate, but note that the NRC staff have concerns about the methodology used in the GoldSim analyses (see PA-11). **Path Forward:** N/A
Response PA-2: N/A	

PA-3	**Comment:** The determination of key radionuclides described in Section 5.2.2 of the PA may not have captured all of the risk significant radionuclides. The determination of key radionuclides is significant to the results of the PA because many of the analyses used to support the PA only include the key radionuclides (e.g., the PORFLOW analyses for Cases B-E). **NRC Response:** The NRC discussion on PA-3 has been combined with PA-4. See below for details. **Path Forward:** N/A
Response PA-3: N/A	

PA-4	**Comment:** Benchmarking based only on key radionuclides identified in the base case analysis does not provide adequate support for the interpretation of alternate-case GoldSim model results. **DOE Response Discussion:** In the DOE RAI response for PA-3, DOE indicated that the inventory list used in the GoldSim model included the less mobile radionuclides even if they were not determined to be key radionuclides. This aspect of the response was adequate. However the response went on to indicate that the dose comparisons for the three key radionuclides Ra-226, Tc-99, and I-129 show good agreement, providing assurance that the behavior of additional radionuclides simulated in the GoldSim model for alternate cases is appropriate. NRC disagrees with this conclusion for two reasons. First, the code comparisons do not show particularly good agreement. The charts are presented with logarithmic scales starting from very low values. The many order of magnitude presentation of very low fluxes and concentrations makes the peak differences appear to be smaller. Examination of the flux curves for the radionuclides that have been benchmarked show differences of a factor of 10 to 30 or more, depending on the time period selected. The confidence in the non-benchmarked GoldSim radionuclides should necessarily be less than this, because they have not undergone the benchmarking exercise. Second, as discussed below for comment PA-5, the benchmarking process itself is not sufficiently transparent to allow NRC to have confidence in the adjustments that were made. **Path Forward:** The following options represent acceptable approaches to addressing this issue: 1) Perform a blind comparison of some radionuclides not included in the previous benchmarking (such as Np-237, Pb-210, U-234) for PORFLOW and GoldSim results for some alternate cases to demonstrate the level of confidence that should be assigned to non-benchmarked radionuclides. The blind comparison would be done by running each model for given radionuclides without iteration on benchmarking factors 2) Perform PORFLOW analyses with the additional radionuclides for the alternate cases. 3) Incorporate an appropriate amount of uncertainty in conclusions regarding the non-benchmarked radionuclides in the alternate cases (least recommended) that factors in the level of agreement achieved between the GoldSim and PORFLOW results and that the additional radionuclides will not have been benchmarked.
Response PA-4: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

PA-5	**Comment:** Additional information is needed about the benchmarking factors and other GoldSim parameter adjustments based on benchmarking to the PORFLOW model. **DOE Response Discussion:** DOE provided additional information discussing the changes that were made in the benchmarking exercise including the basis for some of the changes. The modifications made to account for the different release modeling of Tc was clear, as was the need to make modifications based on the different dimensionality of the flow fields. However, DOE did not sufficiently address the modifications to the saturated zone in reference to the PORFLOW "dilution" provided in the original NRC comment. Although the PORFLOW model is being used for the base (compliance) case, the GoldSim model is used to understand the impact of key uncertainties. Some of those uncertainties, as discussed above, NRC believes should be represented in the base case. Conceptually, the benchmarking process was used to achieve better agreement between the results for the different models. The NRC concern is if the modifications cannot be clearly explained as having a physical basis tied to the conceptual representation of the two different models, then neither model representation may have sufficient predictive power of the future risks from the disposal facility. The benchmarking should increase confidence that each calculation appropriately represents the physical processes and therefore that the risks to future receptors has been appropriately estimated, and it should not be an exercise in getting the results of computer programs to match. **Path Forward:** Provide greater transparency in the benchmarking adjustments. For example, one acceptable approach would be to provide a comparison of the results (unbenchmarked) then a stepwise comparison after each benchmarking change, with each change linked to the conceptual model explaining the physical basis for the change. A diagram of the model, such as a cross section, with the benchmarking changes and the magnitude of the changes would be very useful to help the NRC develop the confidence in the benchmarked model results that the DOE has.
RESPONSE PA-5: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

PA-6	**Comment:** Results of analyses run to times beyond or far beyond the performance period appear to underestimate dose by excluding radionuclides and pathways based on their contribution to the base case analysis at 10,000 or 20,000 years. Although an estimate of the dose at extremely long times is not likely to be necessary for a compliance determination, it is important to understand the basis for any reported results and, when reporting the information, to note important limitations. **DOE Response Discussion:** The answer to this RAI was mostly adequate, but NRC staff has one clarifying question about this RAI response. The first sentence in Section 5.5.1.5 of the PA states, "The peak groundwater pathways doses associated with key radionuclides are calculated for 40,000 years in order that the dose behavior well past the performance period can be evaluated". However, the RAI response implies that the calculation described in this section included all radionuclides. Although the dose at 40,000 years is outside of the period of compliance, the information presented in Figure 5.5-9 may be misleading if all radionuclides were not included in this PORFLOW calculation. **Path Forward** Please provide a list of the radionuclides that were included in the PORFLOW calculation described in Section 5.5.1.5.

RESPONSE PA-6:

The input to the PORFLOW analysis described in SRR-CWDA-2009-00017, Section 5.5.1.5, includes the following radionuclides, I-129, Np-237, Pu-238, Tc-99, Th-230, U-234, and U-235. The principle dose contributing radionuclides, as identified in SRR-CWDA-2009-00017, Section 5.2.2, were captured by this analysis.

Based upon the modeling input identified above, concentrations for the following radionuclides were computed by PORFLOW:

- Ac-227 (from U-235 decay)
- I-129
- Np-237
- Pa-231 (from U-235 decay)
- Pb-210 (from decay of Th-230, Pu-238, and U-234)
- Pu-238
- Ra-226 (from decay of Th-230, Pu-238, and U-234)
- Tc-99
- Th-229 (from decay of Np-237)
- Th-230 (including decay of Pu-238 and U-234)
- U-233 (from decay of Np-237)
- U-234 (including decay of Pu-238)
- U-235

PA-7	**Comment (New):** Model support for the PA is limited and plans for development of additional support are not provided **Basis:** Model support is essential to developing confidence that the PA provides for decisions that are protective of public health and safety. Model support is intended to develop confidence that an appropriate model was used. DOE has done a much better job at explaining the calculations. However, with respect to model support, DOE has referenced ongoing research or provided sensitivity analyses. NRC acknowledges the ongoing research and is fully supportive of it. The sensitivity analysis is useful to understand how the results may change with changes in data or models. However they are of limited use in determining whether the current representation is appropriate and sufficient. The likelihood of making a poor decision increases if model support is limited. NUREG-1854 (NRC, 2007) provides information on appropriate forms of model support. **Path Forward:** Provide acceptable model support for the PA model. If research is ongoing, provide a description of the plans to develop model support including when the information is scheduled to be developed. Consult NUREG-1854 (NRC, 2007) for additional information regarding approaches acceptable to NRC.
Response PA-7: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

PA-8	**Comment (New):** The base case does not represent the current and reasonably expected future conditions. **Basis:** The PA base case scenario is unrealistic and non-conservative in that it (i) does not reflect relevant known conditions, (ii) does not adequately account for uncertainty and variability, and (iii) does not have adequate technical bases. *The base case model is inconsistent with known conditions*. Significant site characteristics that have not been adequately incorporated into the model include the following: • Fractured saltstone is not considered in the base case even though fracturing of saltstone has been observed. In addition, shrinkage has been observed and is not included in the model. (Comment SP-2) • The PA models appear to be inconsistent with observed, advective contaminant releases from Vault 4. (Comments SP-6) • Material interfaces have shown to be relevant to performance; however they are not considered in the PORFLOW model. (Comment VP-5) *The base case model does not adequately account for uncertainty in initial, temporal, and spatial conditions*. NRC concerns with parameter and conceptual model uncertainty include the following: • The hydraulic conductivity and effective diffusion coefficient for saltstone are time-invariant as the base case model does not adequately account for temporal variation. (Comment SP-1; SP-6) • The initial hydraulic conductivity of saltstone does not fully account for uncertainty in scaling from laboratory conditions to full-scale, as-emplaced saltstone. (Comment SP-5) • The PA does not account for uncertainty in the predictions of Eh-pH evolution for cementitious materials. (Comment SP-12) • The PA does not account for uncertainty with respect to vault degradation mechanisms. (Comment VP-2) *The base case does not have adequate technical bases*. NRC concerns with limited model support include the following: • Model support for geotextile filter fabrics and the lateral drainage layers is not commensurate with their expected long-term performance and risk significance. (Comment IEC-8) • The moisture characteristic curves implemented in the base case for intact and fractured cementitious materials, which significantly reduce flow, lack adequate support considering their risk significance. (Comments SP-3; SP-4) • The chemical stability of saltstone provides a significant barrier to transport; however, the basis for the Eh-pH evolution of cementitious materials is very limited. (Comment SP-12) • The basis for the adopted technetium pseudo-Kd of 1,000 mL/g is inaccurate and insufficient. (Comment SP-15)

	• The selected biotic transfer factors lack site-specific data and have very limited support. (Comment B-1) • There is not a sufficient technical basis to exclude the chicken and egg pathway. (Comment B-2) • The effects of radionuclide build-up in irrigated soils may be underestimated. (Comment B-3) • The soil to plant transfer factors may be too low due to the elimination of the leafy plant component. (Comment B-4) DOE has supported the base case with alternative scenarios and one-off sensitivity analyses. Alternative scenarios can be considered towards compliance determination; however, limitations with the assumptions and parameterization make the conservatism of the alternate cases and the synergistic case unclear (see Comment PA-9). DOE has used one-off sensitivity analyses to evaluate the risk significance of certain parameters that are not incorporated into the base case model to demonstrate that the individual parameters do not appreciably impact the estimated dose to the Member of the Public (MOP) during the compliance period. However, this type of analysis, which may result in an insignificant increase in the base case dose, will only identify local sensitivity within the parameter space. When (i) many uncertainties exist, (ii) the margin between compliance and the base case dose is relatively small, and (iii) it is not clear how all of the uncertainties are interrelated, then the resultant dose from the inclusion of these uncertainties could be significant on a cumulative basis even if the increases for individual one-off analyses are insignificant on an absolute basis. **Path Forward:** DOE should establish a base case that has adequate technical bases and appropriately reflects uncertainties to demonstrate with reasonable assurance that the performance objectives can be met.

Response PA-8:

Response will be provided in SRR-CWDA-2011-00044, Revision 1.

PA-9	**Comment (New):** Conclusions about the conservatism of the synergistic case are not clear as certain assumptions appear to be overly optimistic, while other assumptions are potentially conservative. **Basis:** The synergistic case was developed by DOE, based on comments received from the LFRG, to evaluate the impact of simultaneously changing multiple material parameters to account for several potential increased degradation mechanisms from the base case. The PA describes this case as pessimistic. However, NRC staff believes that certain assumptions within the synergistic case render the degree of pessimism or conservatism indeterminate. NRC staff is unable to assess the adequacy of the synergistic case without additional understanding of the balance between (i) the potential conservatism of the flow through the cracked saltstone and (ii) the model limitations that are applicable to all of the cases in the PA. The general limitations of the PA cases include the following: flow through the vaults and saltstone (see Comments PA-10; IEC-8; SP-1; SP-2; SP-3; SP-4; SP-5; SP-6; VP-3; and VP-6); chemical stability of cementitious materials (see Comment SP-12); and appropriateness of the biosphere calculations (see Comments B-1; B-2; B-3; B-4; and B-5). In addition, the synergistic case appears to only include the key radionuclides determined in the base case. Differences in the conceptualization between the synergistic case and the base case could change the key radionuclides (e.g., short-lived radionuclides may be risk significant in the synergistic case with the earlier degradation of the closure cap and the presence of fast pathways and the advective flow present in the synergistic case could result in a set of key radionuclides that differs from the diffusion-dominated base case.) **Path Forward:** The appropriateness of the synergistic case depends on the extent that DOE relies on the synergistic case to demonstrate compliance with the performance objectives. If compliance determination rests heavily on the synergistic case (i.e., the synergistic case is used to estimate the impact from key uncertainties, lack of model support, limited information), DOE should (i) provide discussion on the balance between potential optimisms and conservatisms within the synergistic case, (ii) address the limitations applicable to all of the cases in the PA, and (iii) address the potentially limited subset of radionuclides.
Response PA-9: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

PA-10	**Comment (New):** Assumptions in the PA regarding the conceptual model and parameterization may result in unsupported modeled flow rates through saltstone. **Basis**: Several engineered barriers in the PA provide a significant and long-term impediment to the flow of water through the saltstone wasteform. However, DOE has very limited data to support the performance of several of these key barrier components, which include: • Hydraulic conductivity of saltstone being hydraulically undegraded for 20,000 years in the base case. (See Comment SP-1) • Saltstone as not being fractured in the base case. (See Comment SP-2) • Moisture characteristic curves that are implemented for intact saltstone. (See Comment SP-3) • Moisture characteristic curves that are implemented for fractured saltstone and concrete. (See Comment SP-4) • Initial hydraulic conductivity of saltstone that does not adequately account for uncertainty. (See Comment SP-5) • Geotextile filter fabrics and the lateral drainage layers that provide long-term shedding of water around the vaults. (See Comment IEC-8) • Neglecting disposal unit degradation mechanisms other than sulfate attack. (See Comment VP-2) • Degradation of the vault walls that can result in the bypassing of flow around the saltstone as a potential modeling artifact. (See Comment VP-6) Model support for these flow-related components is limited, however DOE assumptions and parameter selections indicate a consistent bias towards constrained flow through the saltstone wasteform that is unsupported. Reducing the flow of water through the modeled Saltstone system has a compounded effect in that less water is available for the transport of contaminants and the lifespan of reducing conditions in the cementitious materials is prolonged. The timing of the chemical transitions for the walls, floors, and saltstone are dependent on the number of pore volumes that pass through these cementitious materials. Higher flow rates would result in more rapid chemical transitions and generally a more rapid release of redox sensitive radioelements (e.g., Tc-99). As a scoping calculation, NRC staff determined that the flow through saltstone, the floors, and the walls would be more than a factor of 10 higher at the 500 year time period, if the geotextile filter fabric fails at 500 years (i.e., the lower lateral drainage layer has properties similar to the overlying backfill) and the moisture characteristic curves for saltstone and fractured cementitious are comparable to literature values. As a first order approximation, the dose would increase by this factor based on the increased flow rate through saltstone and the floors. However, the contaminant release is compounded due to a more rapid change in chemical transitions for cementitious materials. The timing of these chemical transitions for these cementitious materials would be less than 1/10 of the time assumed in the PA. It appears that the chemical transitions for saltstone, the floors, and the walls would occur well before the 10,000 year compliance period. This result would have a

	significant dose impact as transitions for saltstone, the floors, and the walls are assumed in the PA to occur beyond the 10,000 year compliance period. It should be noted that these scoping calculations still likely contain significant optimisms; for example, the assumption of intact saltstone in the base case, the assumed hydraulic conductivity of saltstone, the limited degradation mechanisms for the disposal units, and the assumption that 100% of the blast furnace slag is available for reaction with the infiltrating water (WSRC-TR-2008-00283). **Path Forward:** Verify that the modeled flow rates are (i) physically reasonable and (ii) consistent with the conceptual models for the various cases. Provide a level of data support for flow through the Saltstone system commensurate with the risk significance of this topic, or use parameter values that are technically defensible. If research is ongoing, provide a description of the plans to develop model support including when the information is scheduled to be developed. Even if research is ongoing, the compliance case needs to be adequately supported based on information that is available at the time the compliance case is developed.

Response PA-10:

Response will be provided in SRR-CWDA-2011-00044, Revision 1.

PA-11	**Comment (New)**: The GoldSim probabilistic model used for sensitivity and uncertainty analyses is not adequately supported. **Basis**: NRC staff has several concerns with the methodology used in the GoldSim calculations: 1) NRC staff has numerous concerns with the implementation of the PORFLOW calculations that provide the input into the GoldSim Calculations (see e.g., PA-8 and PA-10). 2) The GoldSim model incorporates all five cases (Case A-E), and the assumed probability of each case occurring is considered in the uncertainty calculations. NRC staff believes that the probabilities of each case provided in Table 5.6-3 of the PA are unrealistic. For example, the actual probability of Case A is essentially 0 for Vaults 1 and 4 because this case assumes that the saltstone does not crack during the performance period and the saltstone is already known to have cracks. However, in Table 5.6-3, the probability assumed for Case A is 95% for Vault 1 and 85% for Vault 4. 3) The results of the GoldSim model may not be applicable to radionuclides other than the ones that the benchmarking was performed for (see PA-4 and PA-5). In addition, there does not appear to be a good correlation between the PORFLOW and GoldSim results even for the radionuclides that were benchmarked (see Figures 5.6-1 to 5.6-25 in PA and PA-5). 4) It is not clear that there is adequate basis for the uncertainty distributions used (e.g., the uncertainty distributions for inventory [see IN-2] and the uncertainty distributions for K_d values [see SP-18]). Because the GoldSim model was not used as the basis for demonstrating compliance, the NRC staff did not review these calculations to the same extent as the compliance case (Case A) was reviewed. If DOE decides to use this case to demonstrate compliance, the NRC staff will focus more on these calculations and new questions may be identified. **Path Forward**: The concerns listed above need to be addressed. The amount of information needed for this comment depends on the extent to which the GoldSim model will be relied on to demonstrate compliance with the performance objectives of 10 CFR 61. These concerns need to be addressed to the degree that this model is not used to demonstrate compliance or for model support.
Response PA-11: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

PA-12	**Comment (New)** The dose consequences from the disposal of containerized Vault 4 waste in Vault 1 should be evaluated. **Basis** The NDAA states that, "(t)he Commission shall, in coordination with the covered State, monitor disposal actions taken by the Department of Energy". As part of this coordination, SCDHEC and NRC staff discussed a letter written by SCDHEC to the DOE regarding the potential disposal of containerized Vault 4 waste in Vault 1 (SCDHEC, 2010). In this letter, a request for the disposal of containerized waste from Vault 4 operations and soil remediation is described. The NRC staff requires more information about this waste in order to assess compliance with the performance objectives of 10 CFR 61. In particular, the NRC staff must understand the origin and amount of this material. This is possibly important to monitoring the performance of Vault 4 because if this waste primarily consists of soil that has become contaminated due to seeps from Vault 4, then this might show that Vault 4 is not performing as expected. It also would be useful to evaluate whether the PORFLOW model accurately predicts the inventory that has seeped out of Vault 4. If the amount of inventory that has reached the outside of Vault 4 and the surrounding soil is significant, this may indicate that the model underestimates the release from this vault. Also, if any residual radioactivity remains in the soil surrounding Vault 4 following this remediation, this radioactivity could move through the subsurface more rapidly than predicted, especially since the site does not yet have a cover to limit the infiltration. NRC staff is also interested in the effect of this additional waste on the expected dose from Vault 1. In particular, NRC staff is interested in how much additional inventory will be placed in Vault 1 and the effect of this inventory on the expected dose. It is possible that the long-term performance of containerized waste will be different than the long-term performance of grout. An evaluation of the potential effect of the containerized waste on long-term performance should be performed. **Path Forward** Please provide the following information: 1) The inventory of radionuclides that has seeped from Vault 4, including the amount (concentrations and total activity) and location of this inventory. 2) A comparison of the inventory that has seeped from Vault 4 to the inventory predicted by the PORFLOW model to be released from the vault to confirm that the modeling calculations are accurate. 3) An assessment of the dose due to residual radioactivity remaining outside of Vault 4, if any. 4) The inventory in the additional waste that will be added to Vault 1 and the expected dose from this inventory. 5) An evaluation of whether the presence of containerized waste is consistent with the assumptions in the PA for Vault 1 and the potential effect of this waste on the calculated dose.

RESPONSE PA-12:

The referenced letter from SCDHEC to DOE regarding the potential disposal of containerized Vault 4 waste in Vault 1 is part of an ongoing discussion to determine the appropriate path forward with respect to the disposition of the soil that mixed with liquid from Vault 4. As acknowledged in the referenced letter, several studies "must be completed before it will be known if Vault 1 is an acceptable disposal location for the containerized wastes." [ML103340171] These studies include geotechnical investigations and inventory studies of the waste generated from Vault 4 soil remediation activities. These studies are ongoing, thus no final decision has been made with respect to the final disposition of the contaminated soil. If the decision is made to proceed forward with disposal in Vault 1, an Unreviewed Disposal Question Evaluation (UDQE) will be performed to determine the potential impact of the disposal action including an evaluation of the inventory in the remediated soil. DOE will provide any additional information to fully address items 1, 4, and 5 of the Path Forward to the NRC when decisions are made and the information is available to support the NRC's monitoring role related to disposal actions at the SDF.

In regard to item 2 of the Path Forward, the operational conditions (e.g., flush water weeping through vault walls) is not representative of the closure conditions (e.g., inventory leaching from cured saltstone) and therefore comparison to the PA closure modeling is not appropriate. The 2009 PA does account for flush/bleed water that may have seeped into the Vault 4 walls during vault filling operations and is present at the time of closure. The seepage during vault filling operations was evaluated in a UDQE and found to not impact the conclusions of the PA. [SRS-REG-2007-00041] The 2009 PA accounts for this seepage during vault filling operations by including radionuclide inventory in the walls of Vault 1 and Vault 4 as described in Section 4.4.1.1 for Vault 1 and Section 4.4.1.2 for Vault 4 [SRR-CWDA-2009-00017]. Furthermore, the observed condition of the Vault 1 walls and the Vault 4 walls is modeled in the PA by considering an initial saturated hydraulic conductivity of 0.17 cm/sec (as shown in Table 4.2-16) with characteristic curves developed for "fractured concrete" as shown in Figure 4.2-26.

In regard to item 3, the facility is still in an operational condition so any current inventory within the existing containments but outside Vault 4 is not representative of the final closure condition. Therefore, no assessments of this source will be made at this time.

Please note that the condition of the Vault 4 walls have been previously evaluated with respect to the 1992 PA (WSRC-RP-92-1360) and the Composite Analysis (WSRC-RP-97-311) in the UDQE *Evaluation of Liquid Weeping from Saltstone Vault 4 Exterior Walls*, SRS-REG-2007-00041, Revision1 (ML090120134). In addition, the NRC has concluded in their observation report that there is reasonable assurance that Vault 4 can meet the performance objectives in spite of the observed vault conditions if the system is emptied of liquids prior to closure. (ML081290367)

PA-13	**Comment (New)** The dose consequence from early releases from the vaults prior to completion of the closure cap is not considered. **Basis** The performance assessment calculations assume that the closure cap will result in a signification [sic] reduction in the infiltration reaching the vaults starting at the first year of the model. However, the closure cap is not expected to be constructed until the end of the operational period, and there will be no reduction in the amount of precipitation reaching the vault roofs and walls before that time. The reported average precipitation rate for the site is 49 in/yr (124 cm/yr), which is significantly higher than the assumed initial infiltration rate (0.00042 in/yr [0.0011 cm/yr]). It is likely that the amount of leaching will be higher before the closure cap is installed because more water could contact the saltstone during this time. This is especially true for Vaults 1 and 4 because these vaults have had problems with water leaking through the roof and cracks forming in the walls. It is important to understand the potential for early releases to the environment during the time between the placement of the saltstone and the installation of the closure cap and the potential future dose from these releases because these releases could be significant compared to future releases. In addition, the rate of degradation of the vaults might be higher before the backfill and cover are installed. For example, the larger amount of water reaching the vaults during this time could cause the concrete to age more rapidly. Also, the vaults will be exposed to more of the freeze/thaw cycle prior to the backfill being placed around the vaults. The saltstone wasteform would likely experience faster rates of oxidation due to higher rates of oxygen transport associated with air movement through the system compared to post-closure configurations. **Path Forward** Provide an assessment of the dose consequences from the increased amount of water the vaults will be exposed to prior to completion of the closure cap. Also, provide an assessment of the effect of the vaults being initially uncovered on the integrity of the vaults and the oxidation of saltstone.

RESPONSE PA-13:

As described in SRR-CWDA-2009-00017 Sections 3.2.1.1.4, 3.2.1.2.4, 3.2.1.2.6, 3.2.1.3.4, and 3.2.1.3.5, the vaults and future disposal cells contain walls and a roof, which prevent the intrusion of water into the cell. Vaults 1 and 4 have had water intrusion and systems are in place to remove the water from the cells (SRR-CWDA-2009-00017 Section 3.2.1.2.5). Future disposal cells will have a drain system to remove any water infiltrating the cells during the operational period (SRR-CWDA-2009-00017 Section 3.2.1.3.5). In addition, operational control of the disposal units includes the timely removal of water/bleed water associated with saltstone curing, flush water following saltstone emplacement, as well as infiltrating water. Timely removal of water from the disposal units minimizes water intrusion into the saltstone monolith. The drain systems will be maintained until such time that the individual units are

closed.

The closure of an individual disposal unit includes the emplacement of a clean grout cap having the same hydraulic properties as saltstone covering the saltstone monolith, filling the remaining volume to the roof, and the sealing of disposal unit penetrations. These closure activities may be conducted when the disposal unit is at the end of its operational life and will effectively isolate the saltstone monolith from water intrusion. The time between the end of the operational life for a disposal unit and the conducting of its closure activities is expected to be short. In fact, the closure of all of the SDF disposal units is expected to occur within 20 years.

Because the disposal units are designed to preclude water ponding (i.e., sloped roofs) and the temperate climate of South Carolina, increased water infiltration into the concrete and freeze-thaw cycle impacts are not anticipated. With the introduction of operational clean caps and the low diffusion coefficients of the concrete, the impacts of any potential increased oxygen is not risk-significant to the PA results. For example SRR-CWDA-2009-00017 Section 5.6.6.6 presents a sensitivity case in which the Vaults 1 and 4 concrete is assumed to be oxidized at closure. The results indicate that there is an impact to the timing of the peak dose but an actual decrease in the magnitude of the peak dose due to this change. Thus, vulnerability of the disposal units to oxidation and other degradation mechanisms prior to the placement of the closure cap is not considered significant and would have negligible impact on the current performance analysis.

PA-14	**Comment (New)**: The PA does not discuss the existence or implications of calcareous material, or soft zones, underlying Z-Area. **Basis**: Two supporting PA documents (K-ESR-Z-00001; K-ESR-Z-00002) addressed geotechnical issues regarding the calcareous zones at Z-Area that support 10 CFR Part 61.44. In addition to potential stability impacts, these zones have potential implications for other aspects of the future performance of the SDF (e.g. cover integrity, saltstone integrity, and far-field flow and transport [see Comment FFT-4]). It is not clear how these features were or were not considered. As NRC staff only recently became aware of these features, additional information may be requested. **Path Forward**: Provide any additional documentation of calcareous features at Z-Area, including any documentation regarding how these features were addressed in the PA as well as data or analyses from any core, geophysical logs, cone penetrometer test logs and geotechnical borings.
Response PA-14: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

Inventory (IN)

IN-1	**Comment:** 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 for these vaults (Tables 3.3-1 and 3.3-3 in the PA), even when accounting for the decay of these radionuclides to the year 2030. **NRC Response:** The answer to this RAI was adequate. **Path Forward:** N/A
Response IN-1: N/A	

IN-2	**Comment:** More information is needed about the basis for the uncertainty distributions for the radionuclide inventories used in the GoldSim calculations. **DOE Response Discussion:** In the PA, it is stated that "(t)he source variation deals with variability associated with the ability to predict inventories. This source variation not only includes material variability within the waste tanks, but also includes process treatment uncertainty and analytical uncertainty." The ratios of the measured saltcake concentration to the concentration predicted by the Waste Characterization System (WCS) calculations were used as the basis for developing these distributions. The previous NRC comment addressed the basis of using the ratio information for a subset of the radionuclides and applying the ratio for the distributions for all radionuclides. In the response to this comment, DOE stated that the exclusive use of C-14, Cs-137, Pu-239, Sr-90, and U-238 ratio information in developing the uncertainty distributions was due to the lack of data for the other radionuclides. NRC staff understands that limited information is available on these ratios, but the uncertainty distributions are not adequately justified and may not be appropriate for the following reasons: 1) The basis for using salt concentration ratios to represent uncertainty in the supernate is not provided. 2) It is not clear how the uncertainty in removal efficiencies is being represented by uncertainty in the WCS predictions. 3) The basis for using the same uncertainty distributions for radionuclides that are expected to be removed during treatment and those that are not (e.g., Tc) is not clear. 4) It is not clear why the inventory uncertainty factors are used for Vaults 1 and 4. Most of the inventory for these vaults has already been placed into the vaults, so there should not be significant uncertainty associated with either the WCS predictions or the treatment removal efficiency since the inventory in this waste has already been directly measured. The uncertainty distributions assumed for Sr-90, Cs-137, and U-238 are biased towards being less than one such that the use of these uncertainty distributions would result in the mean inventory in the calculations being decreased. This could cause the dose calculated in the GoldSim model for these radionuclides to be underestimated (biased in an arbitrary way to low values).

	Path Forward: As was true for PA-11, the amount of additional information needed on this topic depends on the extent to which DOE intends to use the GoldSim model results for compliance or model support. If the GoldSim model is going to be used for compliance, the basis for the ranges is not adequate. In that case, either more information is needed to justify the distributions, or the distributions should be changed to distributions that are defensible.
Response IN 2: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

IN-3	**Comment**: Information is needed on the process that will be used to ensure that the inventory will be distributed among the FDCs in a configuration that provides reasonable assurance that the performance objectives will be met. **DOE Response Discussion**: The DOE response to this comment stated that the probabilistic model incorporated the variability in the disposal sequence of the waste. As noted in (PA-11 and IN-2) NRC staff has concerns with the methodology used in the GoldSim probabilistic model, including the uncertainty distributions used for the inventory. The DOE response stated that the process of moving the waste through the tank farm to the SPF would tend to move the concentrations of radionuclides in the waste towards the average due to mixing of the waste. NRC staff agrees with this assessment, but there will still be some variability in the concentrations of radionuclides in the different FDCs. Because the compliance case is based on all of the FDCs having a concentration at the average concentration, it would be necessary for the NRC staff to monitor the inventory in each FDC to the average concentration. Information on the methodology that will be used by DOE to assess the actual configuration of inventory in the FDCs would be extremely useful for the NRC to have when writing the updated monitoring plan. **Path Forward**: Provide a description of the strategy that will be used to assess the dose from the actual inventory disposed of in the FDCs.
Response IN-3: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

IN-4	**Comment**: 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. **DOE Response Discussion**: In the response to this comment, DOE staff stated that a cold cap containing clean water will be placed over the saltstone monolith and that the sheet drain system will therefore be filled with clean water at the time of closure. DOE also stated that the drainwater system will be emptied to the maximum extent practical prior to closure. NRC staff agrees that the bleed water from the clean grout will likely dilute the concentration of material in the feed water collection system, but the system will likely still contain some residual amount of radionuclides because the system is likely to respond like a stirred tank reactor and not with plug flow dynamics. NRC staff is interested in understanding the volume and possible concentration of radionuclides remaining in these systems. The DOE response also stated that the transfer lines will be removed and disposed of as LLW, so they will not contribute to dose. NRC staff finds that this portion of the response is adequate **Path Forward**: Provide information on the volume of liquid that is expected to remain in the drain water collection system for Vault 1, Vault 4, and the FDCs. Provide an estimate of the inventory that could remain in these systems at the time of closure.
Response IN-4: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

IN-5	**Comment (New):** Additional information is needed about the Th-230 inventory assumed for Vault 4 and the process used to confirm that all risk-significant radionuclides have been identified as key radionuclides as waste is disposed and final inventory information becomes available. **Basis** One of the key radionuclides identified in the current PA is Ra-226, which is created by ingrowth from Th-230. Neither of these radionuclides was identified as key radionuclides in the 2005 PA. Because of this, the NRC staff is concerned that the process used to predict the inventory for the purpose of the PA may not be capturing all risk-significant radionuclides. Key uncertainties in DOE's ability to estimate disposal inventories may not be adequately accounted for in the estimates. When updated inventory information is developed as waste is disposed, it is important to verify that any changes between the predicted and actual inventory do not result in significant changes to the predicted dose or to the list of key radionuclides. NRC staff is interested in the process used by DOE to confirm this. Additionally, NRC staff would like information on the basis for the assumed inventory of Th-230 in Vault 4 (i.e., was this inventory based on measurements or a calculated value) and NRC staff would like more information on the reason for the underestimation of the Th-230 and Ra-226 inventory in the 2005 PA. This information would help the NRC staff to better understand the cause of this and to have confidence that this type of problem will not occur in the future. **Path Forward** Provide a description of the process that will be used to verify that all key radionuclides have been identified as additional waste is disposed and a more certain inventory is developed. Provide information on the cause of the underestimation of Th-230 and Ra-226 inventory in the previous PA.

RESPONSE IN-5:

Initial inventories of Th-230 and Ra-226 were not estimated in the 2005 SA; rather, the parent radionuclide U-234 was modeled and Th-230 and Ra-226 allowed to in-grow via decay. (WSRC-TR-2005-00074). The inventories were (and still are) believed to be negligible in the disposed saltstone. For this reason their inventories were not included in the 2005 SA. In an effort to ensure all risk significant radionuclides were identified for the 2009 PA, a conservative approach was used to set the radionuclide screening criteria for the SDF PA as described in SRNS-J2100-2008-00004 Section 2. Based on the conservative criteria, DOE is confident that the sufficient constituents have been evaluated. Using these conservative criteria, both Th-230 and Ra-226 were selected for an inventory estimate for the 2009 PA. Based on experience up to 2008, these two radionuclides were not expected to be risk significant and therefore the method chosen to estimate their initial inventory was a conservative one. Both Th-230 and Ra-226 were estimated to be in equilibrium with their parent U-234, at the time of closure, which is a significant conservatism. For example, at a 10,000-year decay time, the Th-230 is actually less than 10% of the U-234 inventory due to the long half-lives of both the U-

234 and Th-230 as presented in CBU-PIT-2005-00040. The same estimate method was used for Th-230 and Ra-226 in the FTF PA Rev. 0 (SRS-REG-2007-00002_Superseded) inventories. Using this conservative methodology, the results from the dose calculations showed Ra-226 to be a significant dose driver. To avoid an over estimate of the risk significance of Ra-226, or U-234, an adjustment was made in developing the inventory estimates for the FTF PA Rev. 1 (SRS-REG-2007-00002) to remove the significant conservatisms in the Th-230 and Ra-226 inventory estimates and replace them with more realistic estimates. [SRR-CWDA-2009-00045]

In the future, the inventories of the risk-significant radionuclides in the SDF disposal units will be primarily based upon laboratory analyses of samples from Tank 50 and not on the conservative methods discussed above. The material sent to the Saltstone Facility will continue to be sampled and analyzed for radiological constituents and the sample results used as the primary means for inventory determinations. This methodology will ensure that risk-significant radionuclides are identified and proper comparisons can be made to inventories modeled in the PA.

The process for identifying variations between the predicted and actual inventories will be addressed in the final inventory document when a disposal unit has completed radioactive filling operations. The description of the approach to be used in the inventory evaluations during future operations will be provided in the response to RAI IN-3.

IN-6	**Comment (New):** Additional information is needed about potential changes to the salt solution feed batch preparation tanks and the sampling methodology that will be used for these tanks. **Basis** As part of the coordination with the State required by the NDAA, the NRC and SCDHEC staff discussed a copy of a letter from SCDHEC to the Department of Energy regarding the replacement of Tank 50 as the feed tank for the SPF (SRR-ESH-2010-00030). According to this letter, DOE is proposing to install two 60,000-gallon (2.3E5 L) Salt Solution Receipt Tanks at the SPF as a replacement for Tank 50 as the feed tank. NRC staff would like information on the sampling approach that will be used for these tanks to assess the inventory of radionuclides that will be disposed of at the SDF. Because the proposed tanks are much smaller than Tank 50 (60,000 gallons [2.3e5 L] instead of 1.3 Mgal [4.9e6 L]), a smaller amount of waste will be mixed in each tank, and the cycle of filling and emptying the tanks will occur more often. The sampling strategy for these tanks may need to be different than for Tank 50. More frequent sampling may be required, particularly if the waste entering these tanks is heterogeneous and there is significant inter-batch variability. This information would be useful for NRC staff in the preparation of the updated plan for monitoring the disposal of salt waste disposal at the SRS. **Path Forward** If Tank 50 is going to be replaced as the salt solution feed tank, please provide updated information on the sampling approach that will be used to verify the inventory that is sent to the SDF.

RESPONSE IN-6:

Consistent with the recently issued Revision 16 of the SRS *Liquid Waste System Plan* (SRR-LWP-2009-00001), current plans are to continue to utilize Tank 50 in low-level waste service and to serve as the collection tank within the H-Tank Farm for the low-level waste streams destined for ultimate disposal in the Saltstone Disposal Facility. Tank 50 will continue to be the sample location for this consolidate low-level waste stream that is the feed stream of the SPF. The Executive Summary (Section 1) of SRR-LWP-2009-00001 states, in part: "*projects Tank 50 utilization as the feed tank for the Saltstone Production Facility (SPF) for the duration of the LW program.*" Discussions had previously been held with South Carolina Department of Health and Environmental Control on the possibility of using alternative tank(s) to collect the low-level waste streams and feed the SPF so that Tank 50 could be placed in high-activity liquid waste service. Due to the advantage of continued use of Tank 50 in its current service, alternative plans have been placed on hold.

Infiltration and Erosion Control (IEC)

IEC-1	**Comment:** The PA does not describe what portion of the water entering the perimeter drainage channel will infiltrate back into the native soil or backfill, or what, if any, effect such infiltration will have on vadose zone or saturated zone flow. **NRC Response:** The DOE response is adequate. The comment will be tracked with monitoring of the final closure cap design. **Path Forward:** N/A
Response IEC-1: N/A	

IEC-2	**Comment:** The cross-sections of disposal units in WSRC-STI-2008-00244 illustrate the lower backfill layer and other materials in the closure cap covering the cells, but do not indicate what materials will be used to backfill around the cells. **NRC Response:** The DOE response is adequate. **Path Forward:** N/A
Response IEC-2: N/A	

IEC-3	**Comment:** Additional information is needed to support conclusions about the long-term performance of the side slopes of the closure cap. **NRC Response:** No additional information is requested, the final cap design will be tracked in monitoring. **Path Forward:** N/A
Response IEC-3: N/A	

IEC-4	**Comment:** During the transition from Bahia grass to a pine tree forest the closure cap could be affected by external factors such as drought or fire, thus changing the assumptions required for the stability calculation. **NRC Response:** The DOE response is adequate. The comment will be tracked with monitoring of the final closure cap design. **Path Forward:** N/A
Response IEC-4: N/A	

IEC-5	**Comment:** Differential settlement could occur due to the presence of the relatively rigid disposal cells within the lower backfill and non-uniform thickness of the backfill. This could affect the drainage efficiency of the upper drainage layer and the integrity of the geomembrane layer. **NRC Response:** The DOE response is adequate. The comment will be tracked with monitoring of the final closure cap design. **Path Forward:** N/A
Response IEC-5: N/A	

IEC-6	**Comment:** Additional justification is needed for the hydraulic conductivity assigned to the foundation layer of the infiltration and erosion cap. **NRC Response:** The DOE response is adequate. **Path Forward:** N/A
Response IEC-6: N/A	

IEC-7	**Comment (New):** The PA should evaluate the potential implications of saturated conditions above the lateral drainage layer in the closure cap. **Basis** Table 47 in WSRC-STI-2008-00244 indicates that beyond 3,200 years the lateral drainage layer is unable to remove a large portion of the infiltrating water, the system saturates above the filter fabric layer, and runoff increases. If saturation occurs, pore pressure build-up in the overlying closure cap layers could directly affect cover stability, vegetation, hydraulic performance of cover materials, and erosion. **Path Forward** Provide (i) the saturation for individual cover layers with respect to time and (ii) the average head on top of each layer for all time periods. If saturated conditions are physically reasonable, provide discussion of the effects of closure cap saturation on stability, vegetation, erosion, and the performance of cover materials under hydrostatic pressure.

RESPONSE IEC-7:

Response will be provided in SRR-CWDA-2011-00044, Revision 1.

IEC-8	**Comment (New):** The PA should provide a technical basis for the long-term performance of the geotextile filter fabric and the upper and lower lateral drainage layers. **Basis** The geotextile filter fabric and the upper and lower lateral drainage layers significantly limit infiltrating water (e.g., the PORFLOW model files indicate that greater than 99% of the water infiltrating through the closure cap is shed via the lower lateral drainage layer at 8,000 years). Accordingly, the performance of the lateral drainage layers can have a significant effect on the dose as was noted in DOE's response to C-12 (RAI-2009-01). The performance of these layers is subject to degradation of the filter fabric layer and the subsequent infilling of the porosity within the lateral drainage layer. As stated in WSRC-STI-2008-00244, "sufficient data is not currently available to estimate the service life of the filter fabric" but that "it will degrade due to oxidation and root penetration". Calculations were presented in Appendix I that account for the reduction in hydraulic conductivity of the lateral drainage layer due to the migration of colloidal clay into the lateral drainage layer. However, it is not clear why larger particles (which would decrease the effective lifetime of the lateral drainage layers) were excluded from these calculations, as there is very limited data regarding the service life of filter fabrics and degradation of the filter fabric is likely to result in the conveyance of larger particles. Infilling of the lateral drainage layers with particles larger than colloids may accelerate infilling and result in a more rapid decrease in the hydraulic conductivity of this layer. A decrease in hydraulic conductivity would limit the ability of the lateral drainage layer to shed water, leading to an infiltration rate that is greater than estimated in the PA. In addition, Figure 4.2-15 in the PA illustrated the change in vertical hydraulic conductivity with respect to time for the lower lateral drainage layer. The PORFLOW model files and Appendix E of SRNL-STI-2009-00115 indicate that vertical hydraulic conductivity of this layer is one order of magnitude greater than stated in the PA. **Path Forward** Due to the risk significance of the lower lateral drainage layer, provide (i) data quantifying the percentage of infiltrating water being shed versus transmitted with respect to time via this layer, (ii) justification for excluding the migration of particles larger than colloids from the overlying backfill materials to the lateral drainage layer, and (iii) support for the long-term performance of this layer. In addition, discuss the apparent discrepancy in the vertical hydraulic conductivity of the lower lateral drainage layer in the PA and the PORFLOW model.
RESPONSE IEC-8:	
Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

Saltstone Performance (SP)

SP-1	**Comment:** Additional justification is required for the assumption that saltstone is hydraulically undegraded for 20,000 years. **DOE Response Discussion:** The DOE response focused on on-going research for overall assessment of degradation and in the case of sulfate attack, short-term experimental measurements that have been completed. The DOE response did not specifically address the NRC comments that had been replicated from a previous review on the expansive phase report. The PA has to account for what is known and conservatively include the impact of uncertainties that are not yet fully understood. Considering the ongoing research, NRC staff believes it is optimistic to assume no hydraulic degradation over 20,000 years. The effects of degradation are evaluated in sensitivity cases, but the conservatism of those cases is unclear. Because the effects are included in a sensitivity case and not in the compliance case, it means the effects are not included in the case used to demonstrate compliance with the performance objectives. The DOE response focused on sulfate attack whereas NRC was interested in a basis for neglecting degradation via all mechanisms. For example, the disposal facilities have embedded steel, some of which is exposed to the atmosphere now or will be exposed to the soil after facility closure. Much of that steel can be seen today to have already experienced corrosion. It is unrealistic to assume that the carbon steel will experience no corrosion. Corrosion of the steel would cause disruption of the surrounding concrete or saltstone. Previous NRC comments on the expansive phase report to which DOE deferred a response include the following: 1) The conclusions of the expansive phase precipitation report are based on geochemical modeling results. It is unclear whether there are data and observations available for comparison to constrain the modeling calculations. 2) The expansive phase study does not consider the effects of organic additives or pozzolanic replacement on the dissolution and precipitation of cement-related compounds, which may have an effect on the generation of expansive phases. Future research could consider the effect that sulfide from the blast furnace slag might have on the phases and reactions present in this system. 3) 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. 4) Geochemist's 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. Subsequent studies might consider expansive phases produced by intermediate or metastable reaction products. 5) The conclusions reached in this study area could be integrated with other

	ongoing or recently completed studies. Dixon (SRNL-STI-2008-00421) 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. **Path Forward** Provide additional basis for assuming no hydraulic degradation of saltstone occurs in the base case or provide an updated base case analysis that reflects estimated saltstone hydraulic degradation (e.g., changes in hydraulic conductivity and effective diffusivity). Specifically, address the comments on the expansive phase report and additional degradation mechanisms. Provide model support for the long-term performance of saltstone and reinforced concrete.

RESPONSE SP-1:

Response will be provided in SRR-CWDA-2011-00044, Revision 1.

SP-2	**Comment:** A basis is required for the modeled extent of saltstone fracturing. **DOE Response Discussion:** The DOE response referenced Case C as including cracks. DOE indicated that the sensitivity studies provide information regarding the effect of crack variability. NRC does not believe 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 as currently represented. The references provided (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 expected that two longitudinal cracks do not adequately reflect the uncertainty associated with the extent 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). **Path Forward** Provide a basis for the extent of fracturing included in the base case representation. Demonstrate how the base case model appropriately represents current observations with respect to cracks. Address the mechanisms noted above as well as other mechanisms by which fractures could increase the rate of subsequent fracturing.
RESPONSE SP-2: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

SP-3	**Comment:** 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. **DOE Response Discussion:** The DOE agreed in their response that the moisture characteristic curve based on the INL dataset is somewhat inconsistent with literature (WSRC-STI-2007-00649). To evaluate the impact of using a modified moisture characteristic curve, the base case was rerun in PORFLOW with the relative permeability set to 1.0. The resulting contaminant release rate was approximately twice that of the base case for Vault 2 during the compliance period. For Vault 4, with the relative permeability equal to 1.0, the release rate of Tc-99 was almost doubled, while the I-129 and Ra-226 rates were each less than a 30% increase over the base case. DOE stated that these increases in release rates would not significantly impact the resulting dose to the MOP during the compliance period. Increases in contaminant release rates of 30% and 100% for one-off sensitivity analyses may result in an 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 an absolute basis. **Path Forward** If adequate justification is not available for the moisture characteristic curves implemented in the PA model for intact saltstone, provide updated results for Case A, B, C, D, the synergistic case, and the sensitivity case in Section 5.6.6.7 that use a characteristic curve for intact saltstone that is more consistent with results in the literature.
RESPONSE SP-3: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

SP-4	**Comment:** Characteristic curves implemented in the PA are based on a continuum approach that does not reflect non-equilibrium flow. **DOE Response Discussion:** The DOE response discussed the effects of transient flow on contaminant leaching. However, NRC staff's concern is the inability of a continuum approach to represent unsaturated flow through porous or fractured media. Unsaturated flow is characterized by non-equilibrium, gravity-driven fingering that can lead to pulsating flow conditions, even in the presence of a steady state infiltration boundary condition (Pruess et al., 1999). Abstraction of unsaturated flow with moisture characteristic curves cannot replicate this flow behavior. Equilibrium flow through unsaturated media can significantly underestimate actual flow rates through a system. **Path Forward** Provide additional model support for unsaturated flow. Model support could include analogs, laboratory experiments, and/or field studies that verify consistency between numerical results and physical measurements. Alternatively, demonstrate that non-equilibrium flow through porous and fractured media does not significantly affect the performance of the system.
RESPONSE SP-4: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

SP-5	**Comment:** 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. **DOE Response Discussion:** The DOE response indicated that additional testing of hydraulic and physical properties has continued to be performed and provided a summary of additional test results. DOE indicated that the baseline test results yielded values of 1.3E-9 to 4.0E-9 cm/s which was consistent with the base case value of 2E-9 cm/s used in the PA. They also indicated that sensitivity analyses were performed to examine the impact of a much higher hydraulic conductivity, and the estimated doses were much less than 25 mrem/yr. The DOE response did not address the monitoring follow-up items provided in the original comment pertaining to the measurement of hydraulic properties. The original comment requested justification for logarithmic averaging of the hydraulic conductivity values for the limited data set with an unknown distribution, which was not provided. Ongoing tests are helpful and fill some important data gaps, but the tests do not capture the full range of conditions that can be expected for actual emplaced saltstone. The test results provided in the comment response have values as large as 9E-9 cm/s for the impact of water to premix ratio and as high as 9E-7 cm/s for a baseline composition with organics, admixtures, and a 60°C cure temperature. Depending on the composition and curing temperature of saltstone, these values could arguably be representative of a reasonable starting point for a base case value. These measurements highlight the need to be conservative when selecting a base case deterministic value for a key parameter such as hydraulic conductivity. As DOE has collected additional measurements, the hydraulic property values have been consistently revised higher. In addition, 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. **Path Forward** Provide adequate support for the hydraulic conductivity value that is implemented in the base case for the PA for intact saltstone. Additional support should include a description of how data from laboratory samples is scaled to represent full-scale, as-emplaced saltstone. Additional support should also address the specific analytical concerns raised in the original comment, including the potential impact of atmospheric CO_2 on the results. Provide justification for the logarithmic averaging of hydraulic conductivity for a limited data set or provide additional data to characterize the distribution.
RESPONSE SP-5: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

SP-6	**Comment:** Additional basis is required for the values of the effective diffusivity of intact and degraded saltstone used in the base case and sensitivity cases. **DOE Response Discussion:** DOE indicated in their response that releases are primarily advection dominated, and calculated Péclet numbers for two separate cases: A and E. Because the Péclet number was large except for very early time periods in Case A, DOE concluded that uncertainty in the effective diffusion coefficient would not have a noticeable impact on calculated peak dose results. The application of Péclet number as a criterion to neglect the importance of diffusion or advection is problematic (Huysmans and Dassargues, 2004). The importance of these transport mechanisms is more appropriately determined by extracting and comparing the model results. The PORFLOW model output files contain the diffusive and advective releases for each radionuclide at one-year time intervals for 20,000 years. NRC review of this data for key radionuclides (e.g., Ra-226, Tc-99, Pu-239) indicates that (i) diffusion strongly dominates radionuclide fluxes at early time periods (as much as four orders of magnitude) and (ii) continues to dominate throughout the 20,000-year period. **Path Forward** Provide a basis for using the effective diffusivity of intact saltstone in the two sensitivity cases that address degraded saltstone or update the sensitivity cases that address degraded saltstone with a value of effective diffusivity that reflects the physical degradation of the wasteform. Provide adequate technical basis for the value of the effective diffusivity of intact saltstone. Similar to SP-5, the values assigned should reflect what has been measured and conservatively reflect the uncertainty associated with the results of experiments that are yet to be completed.
RESPONSE SP-6:	Response will be provided in SRR-CWDA-2011-00044, Revision 1.

SP-7	**Comment:** Additional bases are needed for key assumptions used in the simulation of sulfate attack with the STADIUM code. **DOE Response Discussion:** The DOE response discussed the development of STADIUM by Simco Technologies. Data for blended cements have been developed but are part of a proprietary material database and are unpublished. Minor species are neglected because there is no self-diffusion data available. However, the model has been shown to reproduce experimental observations even though secondary phases are neglected. The DOE response covered most of NRC's concerns. NRC is aware of the high quality of work performed by Simco. However, the use of proprietary unpublished information as a basis does not provide transparency for staff to verify the results. Staff is aware of similar research that has been performed at Vanderbilt University (it may also not yet be published). Research completed as part of the Cement Barriers Partnership showed the modeling results could be sensitive to initial mineralogy. **Path Forward** Given the constraints associated with proprietary information, evaluate whether the blended cement formulations that have been evaluated using STADIUM can be compared to the saltstone and concrete formulations used for saltstone disposal. Communicate the relative agreement between predicted and measured values. With respect to minor species, at a minimum an assumption regarding the neglect of minor species should be tracked and reevaluated as future pertinent research is completed. As research is published, provide a comparison of Simco and Vanderbilt assessment results.
RESPONSE SP-7: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

SP-8	**Comment:** 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. Depending on which initial mineralogy is more appropriate, the conclusions of either report could change. **DOE Response Discussion:** The DOE response indicated why there were differences in the formulations (basically because of timing of the parallel development of products) and that research was ongoing. They also indicated that the uncertainty in Eh and pH transitions of +/- 50% was applied in the uncertainty and sensitivity analyses. The explanation of why the differences were present is useful to provide understanding, but it does not address why the differences are acceptable or what the impact of the differences in composition may be on the conclusions of the reports. The uncertainty range for the Eh and pH transitions has not been demonstrated to capture the differences in the number of pore volumes that would result from the variability in the initial mineral compositions. The assigned uncertainty range is speculative, and the effects are limited to alternate cases and therefore are not reflected in the base case results. **Path Forward** Provide a basis for using different initial mineralogies in the calculations described in the basis of this comment, or provide information that demonstrates the calculation results are not significantly affected by the differences in initial mineralogy. Provide a basis for the uncertainty range assigned to the Eh and pH transitions.
RESPONSE SP-8: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

SP-9	**Comment:** Uncertainty in groundwater composition was not considered in the Geochemist's Workbench simulations to estimate Eh and pH transitions in pore fluids. **NRC Response:** The DOE response is adequate. **Path Forward** N/A
RESPONSE SP-9: N/A	

SP-10	**Comment:** There are indications that some measured plutonium and neptunium sorption coefficients in cementitious materials could reflect solubility rather than sorption, which could lead to a significant overestimate of plutonium and neptunium sorption. **DOE Response Discussion:** Recent DOE-sponsored research indicated that the dissolved concentrations of plutonium and neptunium were solubility limited rather than sorption controlled (SRNL-STI-2009-00636). DOE further stated that the models supporting the PA (i.e., PORFLOW and GoldSim) do not use solubility constraints but instead utilize apparent K_d values. However, it is not clear that solubility effects could be ruled out for the studies that form the basis for these plutonium and neptunium K_d values (WSRC-STI-2007-00640 and SRNS-STI-2008-00045). The use of K_d values based on sorption experiments in which solubility was actually the controlling process could lead to underestimation of the radionuclide release rates. The K_d values measured in WSRC-STI-2007-00640 are extremely high; the solubility limit for plutonium may have been exceeded in these experiments. This report does not include information on the plutonium concentration used in these experiments and how it compares to the solubility limit. This report does state that no solids control samples were included to determine if precipitation was occurring, but the results of these samples were not included in the report. SRNS-STI-2008-00045 provides more information about the methodology used to account for the possibility of precipitation, but it is not clear how the information from the no solids control was used. On page 39, it is stated that the concentrations from samples 621-A, B, and C are used as the initial concentration in the calculation of the K_d. However, based on Table 13, it appears that this sample is not a 'no solids' control and that this sample contains simulated saltstone. Additionally, it seems that this sample is in a reducing environment rather than an oxidizing environment. DOE also stated that the plutonium and neptunium K_d values used in the PA could be overestimated; however these values did not show up as sensitive parameters. In support of this finding, DOE conducted a sensitivity run that set the K_d value for plutonium and neptunium in cementitious material equal to zero in the GoldSim transport model. The results of these sensitivity runs indicated that the dose to the MOP during the compliance period increased by a factor of less than three for the base case; therefore, DOE concluded that any overestimation of plutonium or neptunium K_d values on cementitious materials would not impact the overall conclusions of the PA. In addition to the limitations regarding one-off sensitivity analyses (see Comment PA-8), the relative increase in dose from reducing the K_ds to zero was significant. Table 5.5-2 in the PA indicates that for the base case, plutonium and neptunium each contribute less than 0.05 mrem/yr to the total peak dose of 1.4 mrem/yr in the 10,000-year performance period. In the sensitivity analysis with the K_ds for plutonium and neptunium set to zero, the result was that the total dose more than doubled from the original 1.4 mrem/yr. This large relative increase illustrates the sensitivity of the model to the cementitious material K_d for plutonium and neptunium. In light of the sensitivity of the model to these K_d values and the uncertainties in the PA, a one-off

	sensitivity analysis is not conclusive. **Path Forward** Provide an updated base case that includes technically defensible K_d values for plutonium and neptunium. Provide information on the no solids control samples in WSRC-STI-2007-00640 and SRNS-STI-2008-00045, including the amount of precipitation observed in the no solids control samples (i.e., provide the initial and final concentrations in these samples). Provide information on the aqueous phase used in the no solids control samples and the pH of these samples. In addition, clarify which samples were used for the initial concentration in the K_d equation on p. 39 of SRNS-STI-2008-00045.

RESPONSE SP-10:

Response will be provided in SRR-CWDA-2011-00044, Revision 1.

SP-11	**Comment:** In recent experiments used to help define K_d values for cementitious materials, the distinction between "middle" and "old" age conditions was based chiefly on water chemistry—not on the mineralogical assemblage. It is not clear whether the differences in solid phases for the different stages can be neglected. **DOE Response Discussion:** In the response, DOE states: "(d)ecreased sorption as a result of evolving mineral assemblage is not expected to be significant in the wasteform because the timing of re-crystallization of reducing old-age concrete is after the performance period, and because a decreasing trend between middle-age and old-age cement K_ds was implemented in the PA to account for this type of uncertainty." NRC staff does not agree with this statement because the estimation of the timing of the re-crystallization is based on hydraulic assumptions that the NRC staff does not think are supported (see Comments PA-8 and PA-10). In addition, the comment response states: "(a)s identified above, there is a potential for sorption of key radionuclides onto old-age concrete to decrease with increasing precipitation of quartz as CSH gel dissolves. Any potential impact this may have on underestimating releases from the wasteform are considered insignificant, because countering factors would tend to immobilize these same radionuclides under the old age conditions, either by incorporation into the re-crystallized structures, increased sorption to iron oxyhydroxides, or by increased precipitation of the radionuclide itself, effectively canceling out the effects." NRC staff agrees that some of these factors may act to mitigate the decreased sorption in old-age concrete due to precipitation of quartz. However, NRC staff does not agree with the proposition that the two competing effects will necessarily cancel each other out. The net effect of competing effects is dependent on how strongly the different effects affect the system. Finally, the comment response states: "(i)t is also proposed that the K_ds used in the PA are conservative in that they do reflect a decreasing trend in K_ds from middle-age to old-age cementitious material." NRC staff also does not agree with this logic because whether or not something is conservative is dependent on the actual values chosen, not just the trend in the values. **Path Forward** Depending on the results of research on the predicted flow through the cementitious materials, this comment may be more significant in the future if the transitions are predicted to occur during the performance period. NRC staff will continue to track this topic under monitoring.
RESPONSE SP-11:	Response will be provided in SRR-CWDA-2011-00044, Revision 1.

SP-12	**Comment:** Model support is needed for the process models supporting PA predictions of Eh-pH evolution for cementitious materials. **DOE Response Discussion:** The comment response indicated that research is ongoing, and to account for the preliminary nature of the available information uncertainty and sensitivity analyses were performed. NRC recognizes that additional work will be done to provide model support, and NRC is highly supportive of that work. However, using uncertainty analysis to account for lack of model support is generally insufficient unless it can be demonstrated: i) The 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. Since the model is not adequately supported, it is very difficult to define an appropriate representation for the uncertainty analysis. Uncertainty analysis is a useful tool for use in performance assessment, but should be used very cautiously if at all with respect to model support. **Path Forward** Provide model support for the Geochemist's Workbench results regarding pore fluid volumes necessary for transitions in Eh and pH of pore fluids in cementitious materials (SRNL-TR-2008-00283). For example, model support could include a comparison of model results with the results of pH and Eh measurements in accelerated physical testing using higher flow rates than anticipated in full-scale saltstone. Plans for developing model support may provide appropriate basis, because NRC could verify the implementation of those plans in its monitoring role. However, use of plans for model support could result in the development of information that does not support the decision.
RESPONSE SP-12:	Response will be provided in SRR-CWDA-2011-00044, Revision 1.

SP-13	**Comment:** The effect of limiting the shrinking-core model to the effects of the Eh evolution of saltstone on Tc should be analyzed. **DOE Response Discussion:** DOE provided information to demonstrate that for key radionuclides the transitions from different Eh and pH conditions are not expected to have a significant influence on the results, and therefore switching to a shrinking core model for those radionuclides is not warranted. Tc-99 was the main radionuclide for which the transitions were expected to have a big impact, and so it was included in the shrinking core model. NRC's comment also applied to radionuclides that did not contribute at least 0.05 mrem in the all-pathways base case dose. The approach to modeling the release for those radionuclides could cause them to be defined as important or not. **Path Forward** Demonstrate that the key radionuclide list is not impacted by the type of release model (i.e. shrinking core vs. step transitions) applied. For instance, compare the K_d values assigned at different Eh and pH states, the concentrations of those radionuclides in the waste, and their dose conversion factors for key pathways or provide shrinking core model results for those radionuclides.
RESPONSE SP-13: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

SP-14	**Comment:** Additional information is needed about the basis for the K_d values used for iodine and radium in cementitious materials. **DOE Response Discussion:** In the DOE response to this comment, it is stated that: "(r)esults for iodine partition coefficients onto old-age cements in an oxidizing environment from the same report were not recommended for update because the new results do not correspond to previously reported values (Table 2, WSRC-STI-2007-00640)." NRC staff disagrees with this statement for two reasons: 1) It is not reasonable to ignore data simply because the results are unexpected, and 2) The reducing grout used in WSRC-STI-2007-00640 is based on a different formulation than saltstone (i.e., it contains sodium thiosulfate as a reducing agent). The radium K_d information provided in the DOE comment response is adequate, but NRC staff would like to note that the K_d value for Ra is risk-significant, so it is important for future research to be done on the sorption of Ra on simulated saltstone instead of relying on literature values based on the sorption of strontium. NRC staff would also like to note that it is important for the performance assessment to adequately account for the uncertainty in this parameter value. **Path Forward** K_d values for I that are consistent with measurements made for simulated saltstone should be used in the PA. NRC suggests that future research include the sorption of Ra onto simulated saltstone, particularly under oxidizing conditions.

RESPONSE SP-14:

As mentioned in item #2 above, the reducing grout used in WSRC-STI-2007-00640 is based on a different formulation than saltstone. Subsequent to the issuance of SDF PA, a new evaluation for iodine K_d values sorbed to saltstone was presented in SRNL-STI-2009-00636. Several samples were evaluated including two types of saltstone containing various amounts of slag. Sample TR547 (containing 45% slag) is a baseline mixture more representative of the current saltstone formulation. Based on the results documented in SRNL-STI-2009-00636 for the more representative saltstone formulation, the K_d values that have been utilized in the SDF PA are consistent with measured values; therefore, no changes to the iodine K_d values for saltstone are proposed. An explanation of the uncertainty in these parameter values is provided in the response to SP-18 and is evaluated in Section 5.6 of SRR-CWDA-2009-00017.

As stated in Section 8.2 of the SDF PA, further study may be warranted for an enhanced estimate of the effective transport properties for saltstone contaminant release over time for Ra-226 release modeling, including the possibility of radium co-precipitation. The future work will be considered under the DOE Manual 435.1-1 PA Maintenance Program.

SP-15

Comment:

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

DOE Comment Discussion:

The DOE response to this comment states that,

> *"(t)he technetium K_d value selected for the shrinking core model (1,000 mL/g) is a lower bound on the values recommended in SRNL-STI-2009-00636 for cementitious materials of varying age. The selected value also creates margin in comparison to the recommended value (5,000 mL/g) for young and medium age cementitious material. This margin can be used to account for uncertainty in the recommended value."*

NRC staff does not believe that the "recommended values" of 1000 mL/g or 5000 mL/g are applicable to the saltstone wasteform for the following reasons:

1) *The 5000 mL/g value was measured for a formulation that included a strong reducing agent and is very different than the saltstone formulation.*

According WSRC-TR-2006-00004 and WSRC-STI-2007-00640 the "recommended" value of 5000 mL/g K_d is originally based on a measurement value from Bradbury and Sarott (1995). The Bradbury and Sarott (1995) reference states "(i)n some recent work, using Tc(IV) at trace levels (<10E-11 M) and sodium dithionite as reducing agent, distributions of ~5 m^3/kg (5,000 mL/g) have been reported (Bayliss et al., 1991)."

Because saltstone does not have the strong reducing agent sodium dithionite in it, this measured value is in no way applicable to the saltstone wasteform. In addition, the Bayliss et al., reference cited by Bradbury and Sarrott is a symposium presentation that does not seem to be peer reviewed. It is inappropriate to use a non-peer reviewed source as the basis for a key assumption that strongly affects the calculated dose.

Similarly, staff from SRS have also told NRC staff that research described in Lukens et al., (2005) provided evidence that Tc would be reduced in saltstone (see meeting summary at ML101790054 [NRC, 2010b]). NRC staff disagrees with this statement because the reducing agent Na_2S was added to the waste simulant to reduce it in these experiments and this reducing agent is not added to the salt waste processed at the SPF.

2) *SRS staff measured much lower Tc K_d values for saltstone.*

In SRNL-STI-2009-00636, the measured K_d values for Sample Tr547, which has a composition similar to saltstone, ranged from 9.1 to 56 mL/g after 4 days (Table 10.30). It is not clear why this information is not being considered in the PA, and NRC staff believes that in the absence of any relevant experimental data (i.e., using a wasteform formulation that is comparable to saltstone and does not include a strong reducing agent), it is not reasonable to discount experimental results.

3) *If is unclear if the saltstone pore fluid has reducing conditions.*

The redox conditions of waste are important for the release of Tc from the wasteform

	because under reducing conditions Tc is expected to be retained much more strongly under reducing conditions than under oxidizing conditions. In SRNS-STI-2008-00045, Figure 5, the reported Eh value approaches 0 mV as water flows through the system. Additionally, it is not clear that the Eh measurements were measured correctly. On June 29, 2010, NRC staff and SRS staff held a phone call to discuss the Eh measurements described in this report (see ML101790054 for summary of call). During this call, NRC staff asked what electrode was used and whether the reported values were corrected for the particular reference electrode used (i.e., referenced to a standard hydrogen electrode). SRS site staff stated that the electrode used in their experiments was an Ag/AgCl electrode and that the reported values were read directly from the instrument and were not corrected for the particular electrode used. It is the conclusion of the NRC staff that these redox potentials were incorrectly reported, and based on the half-cell potential of the Ag/AgCl electrode, the true Eh in this system would be 200 mV higher, or less reducing, than was reported. NRC staff recognizes that the K_d tests for the sorption of Tc onto saltstone were intended to evaluate the transport of Tc through the saltstone once it has been released, rather than the release of Tc. However, because no relevant leaching data has been provided to the NRC, the K_d values measured by SRS for Tc represent the best available information on the release of Tc from the saltstone wasteform. NRC staff is unable to conclude that the Tc will be retained by the saltstone wasteform to the extent that was assumed in the PA in the absence of appropriate data that clearly demonstrate that this assumption is valid. NRC staff, absent new information and bases on Tc leaching and K_d's, will use the site-specific K_d values measured by SRS staff for the sorption of Tc onto saltstone in their independent modeling analyses and in their conclusions in the TER. **Path Forward** Use a K_d value that is consistent with the values measured by SRS staff for the saltstone wasteform in the PA.

RESPONSE SP-15:

The mobility of technetium is dependent on its form, with Tc(VII) being highly mobile and the reduced form Tc(IV) being highly immobile. Maintaining technetium in its reduced form (i.e., Tc(IV)) is an important feature of disposal cell and waste form design. Current modeling in the SDF PA assumes that technetium remains in its reduced state until oxidation converts the technetium into its more mobile species. Saltstone is a cementitious waste form containing blast furnace slag that imparts a reducing environment on the technetium. Previous testing had been ineffectual in demonstrating that the saltstone reduces the technetium to the extent assumed in the PA analysis due to the experimental conditions. However, report SRNL-STI-2010-00668 has been recently issued to summarize the results of a literature search regarding the sorption of technetium in cementitious materials containing blast furnace slag and the results of recent technetium sorption laboratory testing. The purpose of the literature review and the laboratory testing was to directly address the NRC's concerns noted in the discussion, specifically: (1) the potential impact of a reducing agent on the transport properties of saltstone, (2) the selection of a Tc K_d value of 1,000 mL/g in cementitious materials under reducing conditions, and (3) if the existing saltstone formula results in reducing

conditions.

Based on SRNL-STI-2010-00668, the following information is provided to directly address the NRC's concerns and to demonstrate that the mobility of technetium within the saltstone monolith can be modeled as a shrinking core with an initial K_d value of 1,000 mL/g. The shrinking core model describes the existence of an oxidized outer layer of cementitious material surrounding a shrinking core of reducing intact saltstone.

- SRS saltstone will reduce Tc(VII) to Tc(IV) in the absence of NaS or sodium dithionite (i.e., strong reducing agents) in a reducing atmosphere.
- Experiments conducted under reducing conditions (< 0.5 ppm $O_{2(g)}$, -585 mV, 2% H_2, pH 11.66) obtained K_d values of approximately 1,000 mL/g in saltstone formulated with 45% slag (nominal saltstone concentration).
- The site-specific reduction capacity value of 820 µeq/g for saltstone is in the realm of literature values that were either measured or theoretically estimated based on thermodynamic calculations of cementitious materials containing blast furnace slag.

The following information was also concluded in SRNL-STI-2010-00668, which addresses issues from previous research related to the impacts of oxygen on the experimental results.

- Only trace concentrations of atmospheric oxygen (30 to 60 ppm O_2; Eh 120 mV) at the high pH levels of cementitious systems is required to maintain technetium as Tc(VII).
- The wide variability of measured K_d values, such that they are either very low, approximately 1 mL/g, or they are very high approximately 1,000 mL/g, appears to be the result of experimental conditions, especially direct controls of oxygen contact with the sample.
- Based upon the information provided in SRNL-STI-2010-00668 (which is included as part of this transmittal package), the modeling parameters utilized in SRR-CWDA-2009-00017 are appropriate and are supported by both existing literature from various sources and experimental results.

SP-16	**Comment:** The basis for the range of reduction capacities over which the shrinking-core model transitions to oxidizing K_d values for technetium is not clear. **NRC Response:** The DOE response is adequate. **Path Forward** N/A
RESPONSE SP-16: N/A	

SP-17	**Comment:** Neglecting gas-phase diffusion of oxygen appears to be inconsistent with the PORFLOW result that saltstone fractures are not completely saturated. **DOE Response Discussion:** The DOE response indicated that the transport of oxygen via the liquid phase is generally sufficient to keep the fracture faces near the oxygen solubility limit for Case C except at times less than 1,000 years, due to the very low flow through the cover system (and fractures) for those time periods. The impact of not addressing gas phase diffusion for Case E was considered minimal during the compliance period, since the FDC barrier is intact and effectively would maintain saturated conditions, thus supporting the assumption of saturated conditions being a barrier to gas-phase oxygen transport. It is not clear to NRC staff that the transport of oxygen via the liquid phase for Case C is realistic or conservative as, (i) the flow of oxygen at early times may be underrepresented in the model due to very low flow through the fractures, (ii) the flow through the fractures in Case C remains low throughout the compliance period, and (iii) the difference between the transport of oxygen via the liquid phase and the gas phase may have an appreciable difference on the dose estimates. In regards to Case E, the impact of ignoring gas phase diffusion due to the performance of the FDCs resulting in saturated conditions is not appropriate as (i) the PORFLOW model appears to indicate saturation levels in the fractures for Case E at 40-50% and (ii) the performance of the FDCs as a hydraulic barrier should be reevaluated in light of recent hydrostatic tests (Comment VP-5). **Path Forward** Provide additional basis for neglecting gas-phase oxygen diffusion in cases representing fractured and degraded saltstone or provide updated dose estimates for cases representing fractured and degraded saltstone considering the potential effects of gas-phase oxygen diffusion.
RESPONSE SP-17: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

SP-18	**Comment:** Additional justification is required for the uncertainty ranges used for K_d values in cementitious materials. **DOE Comment Discussion:** The DOE stated that the selection of the uncertainty distributions used for the K_d values were based on >730 K_d measurements of 8 radionuclides taken from 27 samples collected from the E-Area vadose and aquifer zones, as discussed in WSRC-STI-2008-00285. The provided reference indicated that the 27 depth-discrete samples were collected from a single borehole from E-Area. Variability in the distributions was attributed to general geochemical/geological differences in the site soils. The resulting data was used to estimate the statistical range and distribution of the K_d values for the studied radionuclides. Using these 8 radionuclides as analogues, the distribution coefficient variability was applied to >50 radionuclides. As site-specific cementitious K_d values were not available, the general rules for bounding the sandy sediment were applied to cement. This uncertainty range was considered conservative as SRS sediment is more heterogeneous than cementitious materials, which also contain fewer minerals than natural sediments. NRC staff agrees that natural SRS sediment is likely more heterogeneous and has more minerals than cementitious materials; however, the heterogeneity and number of minerals does not dictate the potential range of K_d values. The relatively limited number of minerals in cementitious materials makes these materials less likely to have as large a range of K_d values as a natural soil; however, even two minerals with different surface chemistry can lead to significant variability. Research by Baur and Johnson (2003) demonstrated that the K_d for selenium can vary by more than two orders of magnitude depending on the cement phase. The limited site-specific K_d data and an insufficient technical basis for adapting K_d values from sediment samples to cementitious materials results in significant uncertainty. An increase in the range of K_d values for cementitious materials over sediment samples is not a basis for uncertainty conservatism. Compensation for insufficient data by an increase in a parameter distribution range provides no additional confidence and it could (i) result an unnecessary degree of conservatism or (ii) result in risk dilution due to an artificial extension in the timing of arrival of a contaminant. The lack of site-specific data demonstrates the importance of an appropriate base case such that a sensitivity and uncertainty analysis could inform research needs to evaluate the variability of data and reduce data uncertainty. Sorption of radionuclides to cementitious materials provides a significant barrier in the PA. Data support for these K_d values should be commensurate with the assumed risk reduction. **Path Forward** Depending on the extent to which DOE will rely on the GoldSim model, provide additional support for using the sandy-soil-based uncertainty distribution for cementitious materials K_d values and a basis for concluding that this approach does not underestimate uncertainty in radionuclide sorption to cementitious materials. For

	example, additional support could include laboratory analyses for risk-sensitive radionuclides. Plans for developing data support may provide appropriate basis, because NRC could verify the implementation of those plans in its monitoring role.

RESPONSE SP-18:

Distribution coefficient measurements of nine radionuclides were obtained from 27 samples collected from the SRS E-Area vadose and aquifer zones with K_d values presented for eight elements in the SDF PA (K_d values for Co-57 and Co-60 were combined in WSRC-STI-2008-00285). [WSRC-STI-2008-00285, Figure 1 and Table 1] The variability, range, and distribution types (lognormal or normal) were assigned and statistical tests were conducted. The variability in the distributions is attributed to general geochemical and geological differences in site soils of the Upland Unit (SRR-CWDA-2009-00017 Section 3.1.4.2). Using these eight elements (nine radionuclides) as analogues, the distribution coefficient variability was applied to more than 50 elemental K_d values. Based on SRNL-STI-2009-00150, the uncertainty ranges used for K_d values in site soils are bounded as indicated in Table 5.6-5 of the SDF PA.

For sandy soils, it was assumed that the 95% confidence level for the mean K_d was 1.5 times the mean, which is a combination of the range for the Aquifer Zone and the Lower Vadose Zone. This would result in a calculation for the minimum ("Min") and maximum ("Max") values of the ranges as follows:

$$\textbf{"Min"} = K_d - (1.5*0.5*K_d) = \mathbf{0.25*K_d}$$

$$\textbf{"Max"} = K_d + (1.5*0.5*K_d) = \mathbf{1.75*K_d}$$

For clayey soils, it was assumed that the 95% confidence level for the mean K_d was 1.0 times the mean, which corresponds to the range for the Upper Vadose Zone. This would result in a calculation for the minimum and maximum values of the ranges as follows:

$$\textbf{"Min"} = K_d - (1.0*0.5*K_d) = \mathbf{0.5*K_d}$$

$$\textbf{"Max"} = K_d + (1.0*0.5*K_d) = \mathbf{1.5*K_d}$$

In general, isotopes in the interstratified clay and sandy Aquifer Zone tend to exhibit the highest degree of variability followed by the silty/clay Upper Vadose Zone. Isotopes in the sandy Lower Vadose Zone, in contrast, have the tendency to exhibit the most consistency in K_d values. Isotopes in the sandy Lower Vadose Zone also have the tendency to display the lowest K_d values compared to those observed in the Upper Vadose and Aquifer Zones. Finally, in general, the 95% confidence window for the mean tends to be approximately one times the mean K_d in the silty/clay Upper Vadose Zone, 0.25 to 0.7 times the mean K_d in the sandy Lower Vadose Zone, and two times the mean K_d in the interstratified Aquifer Zone for most isotopes. [WSRC-STI-2008-00285, Section 4.2]

DOE was not able to identify measurements in applicable literature that addressed the range of uncertainty associated with cement K_d values. While it is recognized that using data related to soil K_d values as a substitute for cement K_d values information is not optimal, the existing uncertainty approach used for soil K_d values was judged to be the best available approach given the lack of measured cement K_d uncertainty information. Given the relative similarity in mineral properties between soils and cementitious materials, and the fact that the sandy soil ranges were the widest of the two soil ranges (i.e., wider than the clayey soil ranges), DOE believes the ranges of uncertainty of cement K_d values would be less than the ranges of K_d

values in sandy soil and therefore, can be reasonably represented by the sandy soil ranges for the purpose of probabilistic modeling.

As part of SDF PA maintenance activities to address NRC TER factors (PA Table 8.2-1), a long-range program plan for on-going testing of degradation mechanisms associated with cementitious hydraulic properties is being developed to identify additional field/lab testing and identify test methods and equipment. Any future studies will be documented through the DOE M 435.1-1 PA Maintenance Program.

SP-19

Comment (New):

Research related to the release of Tc-99 from saltstone appears to be inconsistent with the Tc-99 releases modeled in the PA.

Basis:

As discussed in WSRC-STI-2007-00056, experiments on Tc-99 leaching from saltstone simulated grout were conducted and the results incorporated into PORFLOW modeling. Figure 1 shows the modeled release of Tc-99 according to WSRC-STI-2007-00056 and the 2009 Saltstone PA. The modeled Tc-99 release for WSRC-STI-2007-00056 is approximately 60% over the 10,000-year compliance period for saltstone with a hydraulic conductivity of 1E-9 cm/s, which is slightly less than the assumed hydraulic conductivity in the 2009 PA of 2E-9 cm/s. According to the PORFLOW model files in the 2009 PA, the predicted release of Tc-99 from the saltstone material is 0.6% for the base case and 9.6% for the synergistic case.

The research presented in WSRC-STI-2007-00056 demonstrated the release of Tc-99 due to the presence of residual oxygen for an intact saltstone monolith. Residual oxygen would be consistent with field conditions at the SDF as would the transport of gas and liquid-phase oxygen to the fractured vaults and saltstone. In addition, the saltstone grout has been shown to be fractured which would increase the surface area-to-volume ratio, thereby increasing the oxidation of saltstone.

NRC staff recognizes that research is ongoing and that the results presented in Figure 1 below are based on a modeled system. However, this model is parameterized from experimental results conducted with a saltstone simulant whereas the shrinking core model utilized in the PA is less empirical. Additionally, some key parameters of the shrinking core model, such as the Tc K_d are based on a formulation that is drastically different than saltstone (see SP-15).

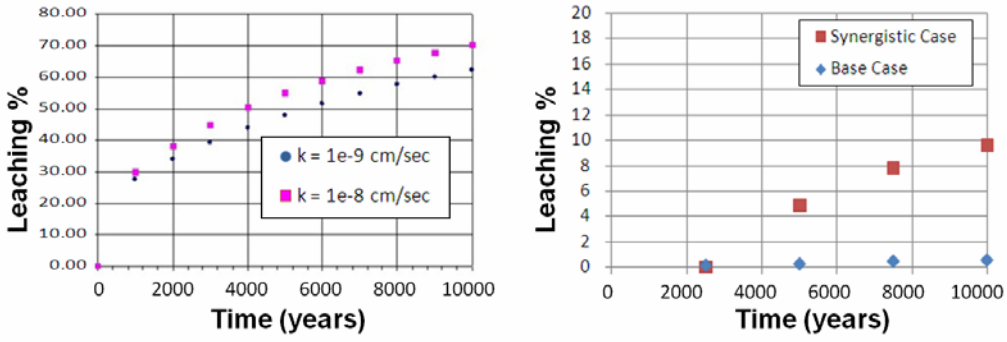

Figure 1: Tc-99 release over the 10,000-year compliance period based on results (a) WSRC-STI-2007-00056 and (b) the 2009 PA model results

	Path Forward The PA should be consistent with relevant research or justification should be provided discussing why it was excluded. Provide any additional references on Tc-99 leaching from saltstone that have not already been provided to the NRC.

RESPONSE SP-19:

Response will be provided in SRR-CWDA-2011-00044, Revision 1.

Vault Performance (VP)

VP-1	**Comment:** Additional analysis is needed to assess the applicability of the degradation mechanisms responsible for the observed fracturing of Vaults1 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. **NRC Response:** The DOE response is adequate at this time; the NRC staff is continuing to review several of the references that were provided by the DOE. **Path Forward** N/A
RESPONSE VP-1: N/A	

VP-2	**Comment:** Additional basis is required for neglecting disposal unit degradation mechanisms other than sulfate attack. **DOE Response Discussion:** The DOE response contained two main elements: sensitivity analyses and ongoing research. A sensitivity case was provided with what DOE believes is pessimistic assumptions that demonstrated the doses would remain marginally below 25 mrem/yr. The DOE response did not address the NRC requests to address corrosion cracking or to provide analog information as technical basis (e.g. model support). The response is mostly complete, but as previously indicated issues or uncertainties should be reflected in the base case and not in an alternative analysis case. For example, the analysis presented shows that the dose could approach 25 mrem/yr. Combined with any other issue that moderately increases the dose independently from this analysis, the performance objective could be exceeded. The original NRC comment provided many technical considerations that should result in modifications to the base case, based on DOE's currently available supporting information. **Path Forward** Update the base-case model to reflect the potential effects of applicable degradation mechanisms and their uncertainties based on currently available information. Provide justification for neglecting other forms of degradation of disposal unit cementitious materials, including alkali silica reaction, corrosion cracking, and other relevant forms of degradation. The justification should address Vaults 1 and 4 floors and roofs as well as FDC walls, roofs, and floors. If maintenance of an alkaline pH near steel components of the disposal units is relied upon to demonstrate steel passivity, the model generating predicted pH values should account for local effects near steel components (e.g., pH depression by carbonation in fractures near steel components) or address why such phenomena can be neglected. A summary of observed reinforcement corrosion of concrete at SRS should be provided. Provide information to demonstrate that modeling of engineered systems in this application is consistent with observed performance of analogous systems at SRS.
RESPONSE VP-2: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

VP-3	**Comment:** The effect of modeling disposal unit floors as completely reducing for the entire performance period, and beyond 20,000 years, should be analyzed **DOE Response Discussion:** The DOE response stated that the exposed surfaces of the vault concrete floor begin oxidizing at time zero. The chemical transition times for the various cementitious materials were presented in Table 4.2-17 of the PA, as computed in PORFLOW except for the shrinking core simulations. The shrinking core model explicitly simulated the oxidation of saltstone and the vault concrete for Tc-99 simulations. The shrinking core model represents a uniform oxidation front with an unreacted core. Rapid transport of redox-sensitive radioelements (e.g., Tc-99) through the oxidized region would occur followed by immobilization once the radionuclide reached the core. However, a fracture in the vault floors would quickly result in a non-reducing fast pathway. It is not clear that DOE has conducted adequate characterization of the floor to support the assumption that the floor is not fractured (initially or at any future time) in the base case. Based on the demonstrated floor performance of Vault 2 (due to cracking near anchor bolts) during recent hydrotesting, it is also not clear that the assumption of no fractures in the floors of Vaults 1 and 4 in the base case is realistic as Vaults 1 and 4 floors also contain anchor bolts. NRC staff understands that Vaults 1 and 4 floors are 24 inches thick versus 8 inches thick for the Vault 2 design which may affect the potential for fracturing at the anchor bolt sites. **Path Forward** Vault floor fractures should be included in the base case or provide a technical basis for not including this feature in the base case in light of limited vault floor characterization and the performance of the FDCs.
RESPONSE VP-3: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

VP-4	**Comment:** The effects of the potential inventory in Vaults 1 and 4 floors on radionuclide release should be analyzed. **NRC Response:** The response is adequate. NRC staff agrees that the potential initial inventory in the floor is likely to be relatively small and not risk-significant. **Path Forward** N/A
RESPONSE VP-4: N/A	

VP-5	**Comment (New):** The uncertainty in the performance of the vaults is not adequately represented in the PA and the PORFLOW model. **Basis** Recent hydrostatic tests for Vault 2, Cells 2A and 2B have demonstrated the complexities and uncertainties regarding the hydraulic integrity of engineered barriers. Discrete engineering features that can drive system performance are not captured within the PA. Features such as material interfaces, the vault liner coating, and anchor bolts led to unanticipated vault performance (SRR-CWDA-2010-00099). DOE has taken steps to eliminate the issues regarding these features; however, the unanticipated leak test results are indicative of optimistic performance assumptions regarding the hydraulic properties of the FDCs, as well as Vaults 1 and 4. The long-term performance of these engineered barriers has uncertainty that is not adequately represented in the PA. The discrete features that have driven the performance of Cells 2A and 2B in the hydrotests are not currently incorporated into the PORFLOW analysis. Accordingly, the model would be inadequate with respect to the representation of these failures. The PORFLOW model does not include the potential for discrete failures beneath the anchor bolts, flawed liner coatings, or the discrete material interfaces. Based on conversations with SRR staff, the recent FDC leaks are not considered significant to the performance of these vaults and they do not significantly impact the conclusions of the PA; the presence of engineered barriers such as the shotcrete and the HDPE-GCL around the FDCs provide a defense in depth. Due to the additional reliance on these engineered barriers and very limited performance data for the relatively unique applications of these barriers, additional model support would provide necessary confidence. Additionally, it is not clear that the HDPE/GCL was a completely redundant barrier i.e., the expected flow and transport through the HDPE/GCL may be correlated to the performance of FDCs. **Path Forward** Provide a technical basis demonstrating that recent events and discrete features will have a negligible impact on the dose results. This may include demonstration that barriers in addition to the FDC vaults will provide compensatory performance, such that the conclusions of the PA are not affected by (i) the observed performance of the FDCs to date and (ii) reasonably expected future performance. Alternatively, reevaluate the expected performance of Vaults 1, 2, and 4 in light of evidence demonstrating the significance of discrete features. Reevaluation of vault performance may indicate that these discrete features should be incorporated into PA models.

RESPONSE VP-5:

The deterministic Base Case (PORFLOW model) represents the best estimate (or expected) performance of the vaults. Alternative system performance configurations including uncertainty and sensitivity analyses were evaluated probabilistically with GoldSim modeling.

The results from this hybrid modeling approach provide reasonable assurance that the performance objectives will be met.

New disposal units will not be placed into service until the engineered barrier capabilities consistent with the SDF PA are valid. In order to mitigate the deficiencies demonstrated by the hydrostatic tests for Disposal Unit 2 (referenced in the NRC's comment), significant design changes have been or will be taken to compensate for the initial construction deficiencies prior to placing the cells in service including adding new construction interface materials (e.g., curbing) and adding new interior "clean" grout pours prior to accepting the units for operations. Cells 2A and 2B have both passed hydrostatic testing. The lessons learned during the construction of Disposal Unit 2 are being incorporated into the design and construction of the future disposal cells including Units 3 and 5 which are currently starting construction.

The items noted in the path forward were supplied as part of the response to RAI VP-1 in SRR-CWDA-2010-00033.

Note that Vaults 1 and 4 have been modeled in the PA with cementitious material properties that reflect the known conditions (i.e., increased hydraulic conductivity to simulate the fractured concrete associated with the macroscopic cracks), as described in Sections 4.2.3.2.4 and 4.4 of SRR-CWDA-2009-00017.

VP-6	**Comment (New):** The bypassing of flow through Vaults 1 and 4 walls may not have a physical basis. **Basis:** In Section 5.6.3.1, DOE discussed the result of water preferentially flowing through the vault walls and around the saltstone wasteform, which is due to the hydraulic model parameters for the Saltstone vaults and wasteform. The hydraulic conductivity of the walls for Vaults 1 and 4 for all cases in the PA is 4 orders of magnitude greater than that of the backfill or native soil. Although degrading the vault walls is locally conservative, globally the result is non-conservative. If there is not a physical basis for the walls to hydraulically degrade to the extent discussed in the PA, then the flow through the saltstone wasteform would be underestimated. **Path Forward** Provide additional support for the assumed hydraulic conductivity of the degraded Vaults 1 and 4 walls that result in the modeled bypassing of flow around the saltstone wasteform.

RESPONSE VP-6:

Response will be provided in SRR-CWDA-2011-00044, Revision 1.

Far-Field Transport (FFT)

FFT-1	**Comment** Additional justification is required for the uncertainty ranges used for K_d values in site soils. **DOE Response Discussion:** The DOE stated that the selection of the uncertainty distributions used for the K_d values were based on >730 K_d measurements of 8 radionuclides taken from 27 samples collected from the E-Area vadose and aquifer zones, as discussed in WSRC-STI-2008-00285. The provided reference indicated that the 27 depth-discrete samples were collected from a single borehole from E-Area. Variability in the distributions was attributed to general geochemical/geological differences in the site soils. The resulting data was used to estimate the statistical range and distribution of the K_d values for the studied radionuclides. Using these 8 radionuclides as analogues, the distribution coefficient variability was applied to >50 radionuclides. WSRC-STI-2008-00285 evaluated the vertical variability of K_d values for 8 different radionuclides; however, lateral variability and radionuclide-specific chemistry may also affect K_d variability. Section 3.1.4.2 discusses the complexity and variability of the local geology and soils and it is not clear that a single borehole from E-Area would be representative of the soils at Z-Area. In addition, it is not clear that the variability in K_d values for 8 radionuclides would adequately capture the variability of all 50+ radionuclides. **Path Forward:** Depending on the extent to which DOE will rely on the GoldSim model, provide additional basis regarding the ability of K_d measurements on sediment samples from a borehole at E-Area for 8 radionuclides to bound the potential variability of >50 radionuclides at Z-Area.

RESPONSE FFT-1:

The geology of the GSA (which includes E Area and Z Area) has "*relatively uniform stratigraphy from F- to H-Area, with the base of the Upland unit at about 280-ft msl, the Barnwell Group/McBean contact at about 200-ft msl, and the McBean/Upper Cretaceous Tuscaloosa contact at about 50-ft to 70-ft msl.*" [SRNL-STI-2010-00148, Section 3.1, Figures 4 and 5] As stated in Section 3.5.1.3 of SRR-CWDA-2009-00017, the base of Vaults 1 and 4, and Disposal Cells 2A and 2B are at 281.5, 269, and 269 feet above MSL, respectively. Therefore, the Upland unit below the SDF comprises, at most, only a few feet of Vadose Zone thickness. Although the depositional environment of the Upland unit can be complex, the composition of the formation predominantly consists of sandy, pebbly clay. The geologic formations below the Upland unit, which comprise the majority of the modeled section, also have very consistent and predictable hydrogeologic characteristics of sands and clays. The aquifers and confining zones are well defined and can be projected across the GSA.

The discussion in Section 3.1.4.2 of SRR-CWDA-2009-00017 focuses on the near-surface geology and surficial soils only. The discussion of a complex depositional environment relates specifically to the Upland unit, which as noted above, represents only a thin layer at the top of the model.

The soil samples utilized to determine K_d values in WSRC-STI-2008-00285 were collected from E-Area borehole BGO-3A. This boring was located approximately 7,000 feet southwest of Z Area. The base of the Upland unit in BGO-3 is defined on Figure 1 of WSRC-STI-2008-00285 at 272 feet above MSL (base of the clayey sand with pebbles). Three of the samples analyzed in WSRC-STI-2008-00285 from the upper section of BGO-3A were above this horizon (Table 1 of WSRC-STI-2008-00285) and are representative of the Upland unit. The remaining 24 samples are representative of the remaining formations.

The eight elements (nine radionuclides) selected for evaluation of K_d variability in WSRC-STI-2008-00285 were chosen to represent a broad range of elemental K_d values that would be expected for the suite of radionuclides in the SDF PA. The elements tested in WSRC-STI-2008-00285 in order of relative diminishing K_d magnitudes included americium, cerium, yttrium, cobalt, cadmium, mercury, cesium, and strontium and have a range of K_d values from approximately 1 mL/g to greater than 5,000 mL/g. As defined in the Response to SP-18, the distribution coefficient variability based on the 95% confidence level for the mean for the eight elements (nine radionuclides) was applied to more than 50 elemental K_d values. The baseline K_d values by soil type reported in SDF PA Tables 4.2-15 and 4.2-18 are the geometric mean for the truncated log-normal distributions utilized in SRNL-STI-2009-00150. Based on this information, it is reasonable to utilize the variability data from WSRC-STI-2008-00285 for the SDF PA probabilitistic modeling.

FFT-2	**Comment:** It is unclear whether any site-specific Kd value measurements have been performed for the sorption of radium to soil. **NRC Response:** The answer to this RAI is adequate, but NRC staff would appreciate receiving the document described in the response to this comment (SRR-CWDA-2010-00057) if it has been issued. If the measured K_d value is significantly different than the one assumed in the PA, the new value should be used in a revised base case. **Path Forward**: N/A

RESPONSE FFT-2:

Modeling for the SDF PA utilized radium and strontium K_d values presented in Table 4.2-15 of SRR-CWDA-2009-00017 of 5 and 17 mL/g for sandy and clayey soils, respectively. SRR-CWDA-2010-00057 was used to support the initial RAI responses and presented site-specific K_d values from preliminary testing for radium and strontium for sandy and clayey soils. SRR-CWDA-2010-00057 also indicated that the final results would be published in a later report.

The subsequent summary report, SRNL-STI-2010-00527, was issued in September 2010. SRNL-STI-2010-00527 Table 5-3 recommends the strontium K_d values utilized in the SDF PA remain at 5 and 17 mL/g for sandy and clayey soils, respectively. For radium, SRNL-STI-2010-00527 Table 5-3 recommends K_d values be increased to 25 and 185 mL/g for sandy and clayey soils, respectively. Because the K_d values for radium have increased, the modeling results for radium in the SDF PA are considered conservative. A copy SRR-CWDA-2010-00057 and SRNL-STI-2010-00527 are included with this response package.

FFT-3	**Comment:** Additional justification is needed for the K_d of selenium in vadose and backfill soils. **DOE Response Discussion:** The DOE stated that a K_d for selenium of 1,000 mL/g is representative of a low pH soil and a low pH soil is considered appropriate as measurements ranged from 5.3 to 5.7 in the Z-Area background well, ZBG-1 (SRNS-TR-2009-00452). The impact of alkaline buffering on the selenium K_d values was evaluated in the probabilistic GoldSim model by using a minimum value of 250 mL/g, to account for the leaching of young-age cement. In addition, DOE ran a bounding sensitivity case using the Case A GoldSim model with both backfill and vadose zone soil K_d values for selenium set equal to zero. The effect on peak dose was less than 3% for Sector B within 20,000 years. DOE stated that the bounding sensitivity analysis provides confidence that lowering the selenium sorption onto soils has a negligible impact on dose results. Although 3% represents a small absolute increase in dose, it represents a large relative increase in the dose derived from Se-79. According to SRNS-TR-2009-00452, the pH range of 5.3-5.7 appears to be too narrow for the Z-Area. Three wells within the Z-Area demonstrated pH values in excess of 5.7 and as high as 7. ZBG-1 represents the background well for the site; however part of NRC staff's concern is the variability across the site, including the potential impact of the cementitious materials in the SDF. In addition, the sensitivity case provided by DOE does not provide confidence as the conservatism of these sensitivity cases is unclear **Path Forward** Depending on the extent to which DOE will rely on the GoldSim model, the selenium K_d values for soil should account for site variability in current conditions as well as reasonably expected future conditions. *SRNS-TR-2009-00452, Z-Area Groundwater Monitoring Report for 2009*, Savannah River Site, Aiken, SC, December 29, 2009. Provide reference Kaplan, D. I., and S. M. Serkiz, 2006. *WSRC-RP-2006-00005, Influence of Dissolved Organic Carbon and pH on Anion Sorption to Sediment*, Washington Savannah River Company, Aiken, SC

RESPONSE FFT-3:

Response will be provided in SRR-CWDA-2011-00044, Revision 1.

FFT-4	**Comment (New):** The PA should discuss the implications of calcareous zones within the far field transport model. **Basis:** The presence of calcareous zones may require alternative flow conceptualization and modeling. Depending on the extent of these zones within the lower Upper Three Runs (UTR) aquifer, a dual porosity and dual permeability model may better represent flow through a porous matrix and open conduits. The presence of open conduits may (i) lead to preferential flow pathways through the subsurface, (ii) influence the location of the point of maximum exposure or compliance point, (iii) lead to decreased natural attenuation (sorption) to subsurface materials due to a decreased solids to pore water ratio, and (iv) lead to reduced K_d values for key radionuclides (e.g., Pu) due to elevated concentrations of carbonate, or non-equilibrium sorption due to the fast transport rates. **Path Forward** 1) Provide a technical basis for neglecting potential open flow conduits within the calcareous zone of the lower UTR aquifer. 2) Provide support for the treatment of the calcareous zones as porous media in transport modeling in light of the fact that decreased solids and presence of high carbonate concentrations can lead to significantly higher mobility for key risk drivers such as Pu. 3) Provide the report, Mueser, Rutledge Consulting Engineers (1986) Saltstone disposal, Z-Area SRP, cited in WSRC-TR-99-4083, "Significance of Soft Zone Sediments at the SRS" that may contain additional information to evaluate the scope and magnitude of calcareous zones in the Z Area subsurface.
RESPONSE FFT-4:	Response will be provided in SRR-CWDA-2011-00044, Revision 1.

Air Pathway (AP)

AP-1	**Comment:** The dose from the radon pathway was not included in the dose assessment of the air pathway (Section 4.5 of the PA). **NRC Response:** The DOE response is adequate. **Path Forward** N/A
RESPONSE AP-1: N/A	

AP-2	**Comment:** The calculations used for the air pathway dose may not have adequately evaluated the dose from this pathway. The materials were assumed to remain constant over the simulation period and degradation of the wasteform and vault does not seem to have been considered. Also, the sensitivity of the calculated land surface flux rates of radionuclides to the assumed moisture content in the cover was also not evaluated. **NRC Response:** The DOE response is adequate. **Path Forward** N/A
RESPONSE AP-2: N/A	

Inadvertent Intrusion (II)

II-1	**Comment:** Key assumptions about the potential pathways of exposure of an inadvertent intruder appear to underestimate dose. **DOE Response Discussion:** In the analysis described in the PA, the intruder analysis was performed at a location of one (1) meter from the boundary of the SDF, which is one meter from some of the FDCs. In response to the NRC comment that the dose at one meter from Vault 4 may be higher, DOE provided a revised analysis that includes the dose at a distance of one meter from Vault 4. NRC staff finds that this portion of the response was acceptable (with the caveat that NRC staff does not agree with the use of Case A [see II-2]). NRC staff also commented that the one-meter concentrations used in the intruder analysis were based on a 15.2 m (50 ft) grid that began at a distance of one meter from the disposal cells. NRC staff did not believe that it was appropriate to average the concentrations over this large a grid because the concentration of radionuclides that decay relatively quickly and are transported slowly may be very different over the 15.2 m (50 ft) cell. The new calculation for Vault 4 provided by DOE conservatively assumes that the concentration at one meter is equal to the concentration calculated under Vault 4. This response is acceptable to the NRC, but the NRC staff would like additional clarification on the Darcy Velocity assumed in this calculation. The calculated dose at a distance of one meter from the FDCs was not evaluated in a similar manner and is still based on the concentration averaged over the 15.2 m (50 ft) grid. NRC staff needs an assessment of the dose at one meter from the FDCs to evaluate if the performance objectives can be met. Additionally, as discussed in more detail in B-2, NRC staff does not agree with the exclusion of the poultry and egg pathway from the dose assessment and NRC staff believes that this should be included in the dose assessment for the intruder. **Path Forward** Provide an evaluation of the effect of the grid size assumption for the FDC. Consider the effect of including the poultry and egg pathway on the intruder (see B-2). Provide a clarification on the Darcy Velocity assumed in the intruder calculation for Vault 4.
RESPONSE II-1: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

II-2	**Comment:** 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. As a consequence, the results of the uncertainty/sensitivity analysis may not capture the true uncertainty in the intruder dose. **DOE Response Discussion:** The response to the RAI provided by DOE states "(t)he deterministic intruder analysis results are based on Case A because Case A represents the reasonably expected degradation configuration for the SDF disposal units". As stated in PA-8, the NRC staff believes that Case A is very optimistic and is not supported. NRC staff needs an intruder assessment that is based on a credible compliance case that includes all risk significant radionuclides to determine that compliance with the performance objectives of 10 CFR 61 can be met. In the RAI response, DOE stated that the SDF PA Section 6.5 presents results that address the effects of uncertainty on the estimation of intruder dose and that the calculated mean dose to the intruder for all cases (Cases A through E) is less than 10 mrem/yr. NRC staff recognizes that the GoldSim uncertainty analysis considers the other, more realistic degradation cases. However, NRC staff has some concerns about the GoldSim modeling calculations (see PA-11), and it is not clear that the doses calculated using the GoldSim model are reasonable or meaningful. Additionally, DOE stated in the RAI response that the potential dose to the intruder associated with the other cases can be inferred based on the dose results at 100 m presented in the SDF PA Section 5.6.6. NRC staff disagrees with this statement because radionuclides that are transported slowly and decay relatively quickly (e.g., Sr-90 and Cs-137) could cause a significant dose at a distance of one (1) meter, but it is unlikely that these radionuclides would travel quickly enough to reach 100 m before decaying. These radionuclides might not be modeled as being released quickly enough in Case A to be a problem at one (1) meter, but they could be released more quickly if more water enters the system than was predicted in that model. **Path Forward** Provide an assessment of the intruder dose based on a realistic and reasonable compliance case.
RESPONSE II-2: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

Biosphere (B)

B-1	**Comment:** The basis for excluding biotic transfer factors from the uncertainty analysis is unclear. **DOE Response Discussion:** The DOE response indicated that uncertainty in biotic transfer factors did not result in large changes to the total dose, therefore uncertainty in the transfer factors were not included in the probabilistic analysis. The absolute changes to dose as a result of biotic transfer factor uncertainty was small, however the relative changes were moderate to significant. The impact of biotic transfer factor uncertainty should be part of the base case assessment. This comment has been expanded to include plant transfer factors and the conceptual approach for developing the values for the distributions and the expected values for the base case. 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 (for plant transfer factors, at almost a three to one ratio compared to values set to the maximum of the distribution). In effect, the distribution is defined such that the actual value will not be lower than the most likely value and the actual value is expected to be higher. These types of distributions are inconsistent with real world data and lack a conceptual basis. Part of the reason for the distributions appears to be the derivation process documented in WSRC-STI-2007-00004. The process is not supported. DOE had derived transfer factors then updated them with a variety of sources, but primarily from PNNL-13421. For many transfer factors, the updating was performed by calculating a geometric mean of the old and PNNL-13421 values. This approach has no basis, and can result in a significant underestimation of biotic pathway doses. For example, the soil to plant transfer factor for Ra (a key radionuclide) was reduced by a factor of 100 from the previous value using this approach. A footnote infers that the PNNL-13421 values are site-specific, but NRC review of the reference indicates that the values are not site-specific but simply represent a different compilation of values. Transfer factors operate on the concentrations derived at the end of the calculation, and can have very broad ranges. Many have very few observations. For the most part, the variance in observed values represents real world variability. Use of a geometric mean can result in a high likelihood of the actual value exceeding the assumed value and exceeding it by a large margin. Without actual site-specific measurements, transfer factors have to be selected conservatively. **Path Forward** Provide technical basis for the expected value and distributions of transfer factors used in the analysis. The results should not be aggregated with a geometric mean transfer factor.

RESPONSE B-1:

The distributions derived in WSRC-STI-2007-00004, Rev. 4 were intended to represent the range of values observed in the various literature sources, and were not developed to be used as the uncertainty range for the selected transfer factor. Although these distributions would be a good starting point to develop the uncertainty range since they are based on documented values, some of the data represented in the distributions have since been updated with newer sources of data, and others are not appropriate to represent site-specific conditions. In addition, a distribution type for the transfer factor data range was not determined in WSRC-STI-2007-00004, Rev. 4. Should DOE decide to include the transfer factors in the uncertainty analysis, careful consideration of the transfer factor data would need to be taken to determine the appropriate uncertainty range and distribution type to be applied to the transfer factor data.

DOE did not develop uncertainty ranges for the transfer factors during initial PA development for several reasons. First, it was not expected that developing uncertainty ranges utilizing the maximum transfer factor values represented in the data range would result in large changes to the total dose. This expectation has been supported by sensitivity runs performed by DOE in "Response B-1" of the NRC RAIs on the SDF PA, SRR-CWDA-2010-00033. Second, a previous independent assessment provided in *Description of Methodology for Biosphere Dose Model BDOSE*, ADAMS Accession Number ML083190829, concluded that applying a distribution to these transfer factors proved to be of no significant importance (Page B-1). Third, DOE was concerned about risk dilution in the uncertainty analysis and desired not to introduce unnecessary and less important stochastic ranges into the analysis. For all these reasons, DOE made a risk-informed decision not to develop and include uncertainty ranges for the transfer factors.

WSRC-STI-2007-00004, Rev. 4 described the specific methodology used for selecting transfer factor values recommended for use in the SRS PAs. As indicated in the RAI, the methodology was to update values using information developed from PNNL-13421. Typically, the original values were replaced with the values from PNNL-13421. In some cases the geometric mean of the original values and the values from PNNL-13421 were determined to be more appropriate. The decision process is described on pages 7 and 8 of WSRC-STI-2007-00004, Rev. 4. Whenever the difference in the original value and the value from PNNL-13421 was more than two orders of magnitude, the geometric mean of the values was calculated and used.

The use of the geometric mean was not without precedence. The main references for the transfer factor data include ORNL-5786, PNNL-13421, and IAEA-364. PNNL-13421 uses the geometric mean to derive transfer factors for elements without transfer factors by calculating the geometric mean of the transfer factors of all the elements in the same chemical group. ORNL-5786 uses the geometric mean for the transfer factor when multiple data sets have different values, especially when the values span across several orders of magnitude. IAEA-364 uses the geometric mean in situations that require space or time averaging of observations. The use of the geometric mean in WSRC-STI-2007-00004, Rev. 4 was similar to the use of the geometric mean by ORNL-5786.

The concern over the application of the geometric mean described in the “Basis” section of this RAI appears to be that this approach could “result in significant underestimation of environmental pathway doses”. An example was provided where the transfer factor for radium

was reduced by a factor of 100 from the previous value using the geometric mean.

Using radium as an example, the original value was 4E-2 and the PNNL-13421 value that was recommended was 3.9E-4. Using the approach described in WSRC-STI-2007-00004, Rev. 4, the difference between these two values rounded to two orders of magnitude, so the geometric mean was used instead of simply replacing the previous value with the value from PNNL-13421, which would have resulted in a decrease by a factor of 100. The geometric mean of the original value (4E-2), the intruder analysis value (6.42E-3), and the recommended replacement value from PNNL-13421 (3.9E-4), is 4.6E-3 (WSRC-STI-2007-00004 Table 5.3). Using this method resulted in selection of a value more conservative than simply selecting the more recently developed values from the PNNL study.

Furthermore, for 18 of the 23 instances where the geometric mean was used in WSRC-STI-2007-00004, Rev. 4, the value from PNNL-13421 was at least two orders of magnitude less than the currently used value, and the geometric mean approach resulted in a more conservative value (relative to PNNL-13421). For the few cases where the geometric mean was non-conservative, the elements involved (i.e., rhenium, titanium, hafnium, and tungsten) were not associated with radionuclides of concern.

In 2010, the International Atomic Energy Agency published Technical Series Report 472, *Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments*, which provides parameter values for radionuclide, bioaccumulation, and transfer in terrestrial and freshwater environments. [IAEA-472] This report supersedes IAEA-364 (*Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments*) which was a key source of data in the PA. SRNL-STI-2010-00447, *Land and Water Use Characteristics and Human Health Input Parameters for use in Environmental Dosimetry and Risk Assessments at the Savannah River Site*, presents additional details on factors utilized in the past and discussion on factors developed for SRS use. This report does not include any data manipulations using a geometric mean. The bioaccumulation factors from this report are used in the response to RAI Comment B-2.

B-2	**Comment:** The animal product pathways included in the dose assessment are the beef, milk, and finfish pathways. A basis for excluding the other animal product pathways (e.g., consumption of poultry and eggs) from the dose assessment is not provided. **DOE Response Discussion:** In the response to this comment, DOE states that the exposure pathway for poultry and eggs is not included in the SDF PA compliance model based on a survey of local practices within 50 miles of the SRS. WSRC-RP-91-17 cites a personal communication from T. Mathis who indicated that it is the local practice to source poultry feed from offsite. Based on this communication, DOE excluded poultry and eggs as an exposure pathway. NRC staff believes that this study does not provide a sufficient technical basis to conclude that chicken feed is currently, or will in the future, be sourced from offsite. In addition, even if the poultry primarily consume commercial feed, the poultry may still consume other things (e.g. bugs and forage) which may contain site-derived radionuclides. Furthermore, the poultry would likely consume groundwater (extracted for domestic or agricultural purposes) from the site. For these reasons, the NRC staff does not believe it is appropriate to exclude the chicken and egg pathways from the PA. **Path Forward:** Provide an evaluation of the dose to the member of the public and intruder from chicken and egg pathways.

RESPONSE B-2:

An evaluation of the dose to the MOP from the poultry and egg ingestion pathways for the PA Base Case (Case A) is provided in the response to this RAI. A similar evaluation will be provided for the intruder in the response to RAI II-1. For the evaluation of this dose pathway, updated information on radionuclide transfer factors are used. These parameters are provided in Tables RAI B-2.1 and RAI B-2.2. Note that the results presented in this response also include a modified soil irrigation buildup factor described in the response to RAI B-3 and revised soil-to-plant transfer factors and a garden productivity yield discussed in the response to RAI B-4.

The poultry and egg ingestion pathway assumes poultry drink water from a well 100 meters from the disposal facility and consume fodder irrigated from the same water source. The fodder is contaminated from direct deposition of irrigation water on plants and from deposition of irrigation water in soil followed by root uptake by plants. Following the poultry consumption of the contaminated water and fodder, the receptor consumes the poultry and eggs. Poultry and egg ingestion pathways are treated separately. The concentration in fodder and the dose is calculated using the following formulas.

$$C_f = C_{GW} \times I \times \left(LEAF + SOIL \times T_{StV}\right) \times F_I$$

Poultry:

$$D = T_P \times \left(FF_P \times C_f \times Q_{FP} + C_{GW} \times Q_{WP}\right) \times DCF \times U_P \times F_P$$

Eggs:

$$D = T_E \times \left(FF_P \times C_f \times Q_{FP} + C_{GW} \times Q_{WP}\right) \times DCF \times U_E \times F_E$$

where:

D	=	dose from 1-year consumption of contaminated poultry or eggs (rem/yr)
C_f	=	radionuclide concentration in fodder (pCi/kg)
C_{GW}	=	radionuclide concentration in groundwater from the 100-meter well (pCi/L)
I	=	irrigation rate (= 3.6 L/m^2-d), SRR-CWDA-2009-00017, Table 4.6-6
$LEAF$	=	radionuclide deposition and retention rate on the vegetation's leaves defined in SRR-CWDA-2009-00017, Section 5.4.1.1 (m^{2}d/kg)
$SOIL$	=	radionuclide deposition and buildup rate in the soil, (m^{2}d/kg), see the response to RAI B-3
T_{StV}	=	soil to vegetation ratio (unitless), Table RAI B-2.1
F_I	=	fraction of the time vegetation is irrigated (= 0.2), SRR-CWDA-2009-00017, Table 4.6-6
T_P	=	poultry transfer coefficient (d/kg), Table RAI B-2.2
T_E	=	egg transfer coefficient (d/kg), Table RAI B-2.2
FF_P	=	poultry or egg intake fraction from irrigated field/pasture (= 1.0)
Q_{FP}	=	consumption rate of fodder by poultry (= 0.1 kg/d), ML083190829, Table A-1
Q_{WP}	=	consumption rate of water by poultry (=0.3 L/d), ML083190829, Table A-1
DCF	=	ingestion DCF (rem/µCi), SRR-CWDA-2009-00017, Table 4.7-1
U_P	=	human consumption rate of poultry (= 25 kg/yr), ML083190829, Table A-1
U_E	=	human consumption rate of eggs (= 19 kg/yr), ML083190829, Table A-1
F_P	=	fraction of poultry produced locally (= 0.306), ML083190829, Table A-1
F_E	=	fraction of eggs produced locally (= 0.306), ML083190829, Table A-1

Table RAI B-2.1 provides the transfer factors utilized for this response and the parameters used in the PA. The factors used in this response are based on SRNL-STI-2010-00447, which was issued after Revision 0 of the PA. This report presents additional details on factors utilized in the past and discussion on factors developed for future use. This report also established a standardized source for transfer factors that represent current data including IAEA-472. Issued in 2010, IAEA-472 provides values for transfer factors in terrestrial and freshwater environments. This report supersedes IAEA-364, which was a key source of data in PNNL-13421, which was used as a primary data source for Revision 0 of the PA.

SRNL-STI-2010-00447 did not include feed-to-poultry and feed-to-egg transfer factors. In order to account for local poultry and egg farmers that use free-range methods or home-grown fodder as feed, a methodology similar to that described above for SRNL-STI-2010-00447 was used to determine the feed-to-poultry and feed-to-egg transfer factors. The PNNL-13421 transfer factors were used and updated with the transfer factors from IAEA-472. Elements in the model that feed-to-poultry or feed-to-egg transfer factors were not found were assigned a zero value. Table RAI B-2.2 provides the bioaccumulation factors for the poultry and egg pathways used for this response.

The dose to the MOP in Sector B (location of the peak dose within the first 10,000 years after

closure) and in Sector I (location of the peak dose within 20,000 years after closure) from the ingestion of poultry and eggs are provided in Table RAI B-2-3. The peak dose to the MOP within 10,000 years after closure is in Sector B and is 2.5E-03 mrem/yr in year 9,820 for the egg ingestion pathway and 3.3E-04 mrem/yr in year 9,980 for the poultry ingestion pathway. The peak dose to the MOP within 20,000 years is in Sector I in year 15,080 and is 2.5E-02 mrem/yr for the egg ingestion pathway and 6.2E-04 mrem/yr in Sector B in year 16,240 for the poultry ingestion pathway. The contributions to the total peak dose to the MOP provided by the poultry and egg ingestion pathways are provided in Table RAI B-2.4. As indicated in Table RAI B-2.4 the poultry and egg ingestion pathways are not significant contributors to the total dose.

The total peak doses to the MOP provided in Table RAI B-2.4 are less than the values reported in SRR-CWDA-2009-00017, Section 5.5.1.2. The peak dose to the MOP within 10,000 years reported in SRR-CWDA-2009-00017 is 1.4 mrem/yr compared to 0.9 mrem/yr reported in Table RAI B-2.4. The peak dose to the MOP within 20,000 years reported in SRR-CWDA-2009-00017 is 3.1 mrem/yr compared to 2.0 mrem/yr reported in Table RAI B-2.4. These reductions in dose from the values reported in SRR-CWDA-2009-00017 are attributed to a decrease in the dose from the fish ingestion pathway (caused by a decrease in the water-to-fish transfer factor for Ra-226) and a decrease in the vegetable ingestion pathway (caused by an increase in the vegetation production yield discussed in the response to RAI B-4).

Table RAI B-2.1: Transfer Factors for Vegetable, Milk, Beef, and Fish Pathways

	Soil-to-Plant (unitless)		Feed-to-Milk (d/L)		Feed-to-Beef (d/Kg)		Water-to-Fish (L/kg)	
Element	RAI (a)	PA (b)	RAI (c)	PA (d)	RAI (e)	PA (f)	RAI (g)	PA (h)
Ac	6.11E-05	6.83E-05	2.00E-05	2.00E-05	4.00E-04	4.00E-04	25	25
Al	1.27E-04	1.27E-04	2.06E-04	2.06E-04	1.50E-03	1.50E-03	51	500
Am	7.33E-05	6.83E-05	4.20E-07	1.50E-06	5.00E-04	4.00E-05	240	30
C	1.37E-01	1.37E-01	1.20E-02	1.20E-02	3.10E-02	3.10E-02	3	3
Cf	6.11E-05	6.83E-05	1.50E-06	1.50E-06	4.00E-05	4.00E-05	25	25
Cl	3.49E+00	1.37E+01	1.70E-02	1.70E-02	1.70E-02	2.00E-02	47	50
Cm	1.27E-04	8.39E-05	2.00E-05	2.00E-05	4.00E-05	4.00E-05	30	30
Co	2.48E-02	1.31E-02	1.10E-04	3.00E-04	4.30E-04	1.00E-02	76	300
Cs	6.85E-03	9.00E-01	4.60E-03	7.90E-03	2.20E-02	5.00E-02	3,000	3,000
Eu	3.90E-03	3.90E-03	3.00E-05	3.00E-05	2.00E-05	2.00E-05	130	30
Gd	3.90E-03	3.90E-03	3.00E-05	3.00E-05	2.00E-05	2.00E-05	30	30
H	4.80E+00	4.80E+00	1.50E-02	1.50E-02	0.00E+00	1.20E-02	1	1
I	1.32E-02	7.80E-03	5.40E-03	9.00E-03	6.70E-03	4.00E-02	30	40
K	2.54E-01	1.07E-01	7.20E-03	7.20E-03	2.00E-02	2.00E-02	3,200	1,000
Nb	2.18E-03	4.88E-03	4.10E-07	3.20E-05	2.60E-07	2.90E-04	300	300
Ni	2.18E-02	1.17E-02	9.50E-04	1.60E-02	5.00E-03	5.00E-03	21	100
Np	3.91E-03	2.54E-03	5.00E-06	5.00E-06	1.00E-03	1.00E-03	21	21
Pa	6.11E-05	4.18E-04	5.00E-06	5.00E-06	4.47E-04	4.47E-04	10	10
Pb	5.18E-03	1.17E-03	1.90E-04	2.60E-04	7.00E-04	4.00E-04	25	300
Pd	1.28E-02	7.80E-03	1.00E-02	1.00E-02	4.00E-03	4.00E-03	10	10
Pt	4.88E-03	4.88E-03	5.15E-03	5.15E-03	4.00E-03	4.00E-03	35	35
Pu	1.97E-05	2.15E-04	1.00E-05	1.10E-06	1.10E-06	1.00E-05	30	30
Ra	1.19E-02	4.64E-03	3.80E-04	1.30E-03	1.70E-03	9.00E-04	4	50
Se	1.89E-02	5.14E-02	4.00E-03	4.00E-03	1.50E-02	1.50E-02	6,000	170
Sm	3.90E-03	3.90E-03	3.00E-05	3.00E-05	3.16E-04	3.16E-04	30	30
Sn	2.27E-03	1.17E-03	1.00E-03	1.00E-03	8.00E-02	8.00E-02	3,000	3,000
Sr	1.23E-01	9.75E-02	1.30E-03	2.80E-03	1.30E-03	8.00E-03	2.9	60
Tc	1.79E+01	4.68E-02	1.87E-03	1.87E-03	6.32E-03	6.32E-03	20	20
Th	3.14E-04	6.44E-05	5.00E-06	5.00E-06	2.30E-04	4.00E-05	6	100
U	6.69E-03	2.34E-03	1.80E-03	4.00E-04	3.90E-04	3.00E-04	1	10
Zr	7.80E-04	1.95E-04	3.60E-06	5.50E-07	1.20E-06	1.84E-04	22	300

(a) SRNL-STI-2010-00447, Table 2
(b) SRR-CWDA-2009-00017 , Table 4.6-1
(c) SRNL-STI-2010-00447, Table 3
(d) SRR-CWDA-2009-00017 , Table 4.6-2
(e) SRNL-STI-2010-00447, Table 4
(f) SRR-CWDA-2009-00017 , Table 4.6-3
(g) SRNL-STI-2010-00447, Table 5
(h) SRR-CWDA-2009-00017 , Table 4.6-4

Table RAI B-2.2: Transfer Factors for Poultry and Egg Pathways

Element	Feed-to-Poultry (d/Kg)	Feed-to-Egg (d/Kg)
Ac	6.00E-03	4.00E-03
Al	0.00E+00	0.00E+00
Am	6.00E-03	3.00E-03
C	0.00E+00	0.00E+00
Cf	6.00E-03	4.00E-03
Cl	3.00E-02	2.70E+00
Cm	6.00E-03	4.00E-03
Co	9.70E-01	3.30E-02
Cs	2.70E+00	4.00E-01
Eu	2.00E-03	4.00E-05
Gd	2.00E-03	4.00E-05
H	0.00E+00	0.00E+00
I	8.70E-03	2.40E+00
K	4.00E-01	1.00E+00
Nb	3.00E-04	1.00E-03
Ni	1.00E-03	1.00E-01
Np	6.00E-03	4.00E-03
Pa	6.00E-03	4.00E-03
Pb	8.00E-01	1.00E+00
Pd	3.00E-04	4.00E-03
Pt	0.00E+00	0.00E+00
Pu	3.00E-03	1.20E-03
Ra	3.00E-02	3.10E-01
Se	9.70E+00	1.60E+00
Sm	2.00E-03	4.00E-05
Sn	8.00E-01	1.00E+00
Sr	2.00E-02	3.50E-01
Tc	3.00E-02	3.00E+00
Th	6.00E-03	4.00E-03
U	7.50E-01	1.10E+00
Zr	6.00E-05	2.00E-04

Table RAI B-2.3: Peak Dose to the MOP in Sectors B and I from Egg and Poultry Ingestion for Case A

Sector B in 10,000 Years Egg Ingestion (Year 10,000)			Sector B in 10,000 Years Poultry Ingestion (Year 9,980)		
Radionuclide	Dose (mrem/yr)	Contribution	Radionuclide	Dose (mrem/yr)	Contribution
Ra-226	1.6E-03	63.0%	Ra-226	2.1E-04	62.0%
Tc-99	4.5E-04	17.6%	Pb-210	9.8E-05	29.7%
I-129	3.9E-04	15.6%	Cs-135	2.2E-05	6.6%
Pb-210	9.1E-05	3.6%	Tc-99	3.7E-06	1.1%
Cs-135	2.4E-06	0.1%	I-129	1.9E-06	0.6%
Total	2.5E-03	- -	Total	3.3E-04	- -
Sector B in 20,000 Years Egg Ingestion (Year 16,240)			Sector B in 20,000 Years Poultry Ingestion (Year 16,240)		
Tc-99	1.9E-02	87.6%	Tc-99	2.5E-04	40.8%
Ra-226	1.7E-03	7.5%	Ra-226	2.1E-04	33.8%
I-129	9.8E-04	4.4%	Pb-210	1.0E-04	16.6%
Pb-210	9.8E-05	0.4%	Cs-135	4.7E-05	7.5%
Cs-135	5.3E-06	< 0.1%	I-129	4.7E-06	0.7%
Pa-231	9.7E-07	< 0.1%	Pa-231	1.9E-06	0.3%
Np-237	6.5E-07	< 0.1%	Np-237	1.3E-06	0.2%
Total	2.2E-02	- -	Total	6.2E-04	- -
Sector I in 10,000 Years Egg Ingestion (Year 10,000)			Sector I in 10,000 Years Poultry Ingestion (Year 10,000)		
I-129	7.5E-04	94.1%	Ra-226	5.6E-06	47.2%
Ra-226	4.4E-05	5.5%	I-129	3.6E-06	30.2%
Pb-210	2.5E-06	0.3%	Pb-210	2.7E-06	22.4%
Tc-99	1.6E-07	< 0.1%	K-40	2.8E-08	0.2%
K-40	5.3E-08	< 0.1%	Tc-99	2.0E-09	< 0.1%
Total	8.0E-04	- -	Total	1.2E-05	- -
Sector B in 20,000 Years Egg Ingestion (Year 15,080)			Sector B in 20,000 Years Poultry Ingestion (Year 15,080)		
I-129	2.5E-02	99.5%	I-129	1.2E-04	83.7%
Ra-226	1.2E-04	0.5%	Ra-226	1.6E-05	11.0%
Pb-210	7.1E-06	< 0.1%	Pb-210	7.5E-06	5.3%
Tc-99	6.1E-07	< 0.1%	K-40	4.8E-08	< 0.1%
Total	2.5E-02	- -	Total	1.4E-04	- -

Table RAI B-2.4: Contribution to the Peak Dose in Sectors B and I from the Egg and Poultry Ingestion Pathways

Peak Dose in Sector B in 10,000 Years (Year 9,980)			Peak Dose in Sector B in 20,000 Years (Year 15,080)		
Pathway	Dose (mr/yr)	Contribution	Pathway	Dose (mr/yr)	Contribution
Water Ingestion	6.9E-01	77.1%	Water Ingestion	1.3E+00	65.1%
Vegetable Ingestion	1.1E-01	11.9%	Fish Ingestion	3.7E-01	18.7%
Inhalation	4.6E-02	5.1%	Vegetable Ingestion	2.1E-01	10.4%
Fish Ingestion	3.5E-02	3.9%	Inhalation	5.2E-02	2.6%
Beef Ingestion	3.9E-03	0.4%	Milk Ingestion	2.4E-02	1.2%
Milk Ingestion	2.8E-03	0.3%	Beef Ingestion	1.5E-02	0.8%
Egg Ingestion	2.4E-03	0.3%	Egg ingestion	1.4E-02	0.7%
Poultry Ingestion	3.3E-04	< 0.1%	Poultry Ingestion	4.4E-04	< 0.1%
All other pathways	8.0E-03	0.9%	All other pathways	9.3E-03	0.5%
Total	9.0E-01	- -	Total	2.0E+00	- -
Peak Dose in Sector I in 10,000 Years (Year 10,000)			Peak Dose in Sector I in 20,000 Years (Year 15,080)		
Water Ingestion	5.8E-02	53.9%	Water Ingestion	1.4E+00	66.4%
Fish Ingestion	3.5E-02	33.1%	Fish Ingestion	3.7E-01	18.3%
Vegetable Ingestion	8.8E-03	8.2%	Vegetable Ingestion	2.1E-01	10.0%
Inhalation	1.9E-03	1.8%	Milk Ingestion	5.1E-02	2.5%
Milk Ingestion	1.6E-03	1.5%	Beef Ingestion	2.5E-02	1.2%
Beef Ingestion	8.4E-04	0.8%	Egg ingestion	2.5E-02	1.2%
Egg ingestion	8.0E-04	0.7%	Inhalation	7.2E-03	0.4%
Poultry Ingestion	1.2E-05	< 0.1%	Poultry Ingestion	1.4E-04	< 0.1%
All other pathways	2.9E-05	< 0.1%	All other pathways	6.5E-05	< 0.1%
Total	1.1E-01	- -	Total	2.0E+00	- -

B-3	**Comment:** The effects of radionuclide build-up in irrigated soils may be underestimated. **DOE Response Discussion:** The DOE response indicated that use of a 30-year build-up time as compared to a 183-day build-up time for radionuclides in irrigated soils did not result in large changes to the total dose; therefore the effects did not need to be included in the base case. Most releases from the SDF are expected to occur slowly over thousands of years. The 30-year buildup time may be exceeded for long-lived radionuclides, however NRC acknowledges that the assessment provided did not consider losses from erosion and leaching. Ambiguity could be reduced by including expected gain and loss processes to determine equilibrium build-up factors. The absolute changes to dose as a result of increased build-up times were small; however the relative changes were significant. The impact of build-up time uncertainty should be part of the base case assessment. **Path Forward:** Include build-up of radionuclides during multiple years of irrigation in the base case PA model.

RESPONSE B-3:

In the initial response to RAI B-3 provided in SRR-CWDA-2010-00033, Rev. 1, the build-up of radionuclides in the soil from irrigation was conservatively assessed by using a 30-year build-up time with no credit taken for leaching. To assess more realistically the impact of soil build-up, credit is taken for leaching and the build-up time is considered to be 25 years based on SRNL-STI-2010-00447.

The expression for soil build-up [$SOIL$] is defined in the expressions provided below and is based on the formulation provided in *Description of Methodology for Biosphere Dose Model BDOSE*, ADAMS Accession Number ML083190829.

$$SOIL = \frac{1 - e^{-\lambda_B t_b}}{\rho_S \times \lambda_B}$$

$$\lambda_L = \frac{P_R + I_R - E_R}{S_D \times \left(S_M + \rho_{SS} \times K_d\right)}$$

$$\lambda_B = \lambda_i + \lambda_L$$

Where:

$SOIL$	=	*radionuclide deposition and buildup rate in the soil (m^2d/kg)*
ρ_S	=	*areal surface density of soil (kg/m^2), SRR-CWDA-2009-00017, Table 4.6-6*
λ_B	=	*soil buildup rate (1/d)*
λ_i	=	*radiological decay constant (1/d)*
λ_L	=	*soil retention rate (1/d)*
P_R	=	*precipitation rate (= 49.14 in/yr), WSRC-STI-2008-00244, Table 47*
I_R	=	*irrigation rate (= 51.7 in/yr), based on 3.6 L/m^2-d, SRR-CWDA-2009-00017, Table 4.6-6*
E_R	=	*evapotranspiration rate (= 32.57 in/yr), WSRC-STI-2008-00244, Table 47*
S_D	=	*depth of garden (= 15 cm), SRR-CWDA-2009-00017, Table 4.6-6*
S_M	=	*soil moisture content (= 0.39), based on the porosity of the vadose zone soil provided in SRR-CWDA-2009-00017, Table 4.2-14 and assuming 100% saturation*
ρ_{SS}	=	*density of sandy soil (= 1.65 g/cm^3), SRR-CWDA-2009-00017, Table 4.2-14*
K_d	=	*distribution coefficient (mL/g), SRR-CWDA-2009-00017, Table 4.2-15 (Vadose Zone)*
t_b	=	*buildup time of radionuclides in soil (= 9,125 days), SRNL-STI-2010-00447, Table 1*

To illustrate the impact of this parameter on the resulting soil concentrations, the term SOIL is provided in Table RAI B-3.1 using three different parameters: 1) build-up time of 0.5 year with no leaching (used in the PA), 2) build-up time of 25 years with no leaching (to illustrate the impact from leaching), and 3) build-up of 25 years with leaching (case to be used in dose calculations provided in this RAI response package).

Table RAI B-3.1: Soil Build-up Factors for Various Parameters

Radionuclide	Half-life (yrs)	SOIL-1 (a)	SOIL-2 (b)	Ratio SOIL-2 to SOIL-1	K_d (mL/g) (c)	SOIL-3 (d)	Ratio SOIL-3 to SOIL-1
Ac-227	2.18E+01	2.1E-03	7.2E-02	35	1,100	6.7E-02	32.40
Al-26	7.17E+05	2.1E-03	1.0E-01	50	1,300	9.7E-02	46.65
Am-241	4.32E+02	2.1E-03	1.0E-01	49	1,100	9.4E-02	45.23
Am-242m	1.83E-03	2.1E-03	9.8E-02	47	1,100	9.1E-02	43.50
Am-243	1.41E+02	2.1E-03	1.0E-01	50	1,100	9.6E-02	46.04
C-14	5.70E+03	2.1E-03	1.0E-01	50	0	1.4E-04	0.07
Cf-249	3.51E+02	2.1E-03	1.0E-01	49	1,100	9.4E-02	45.03
Cf-251	8.98E+02	2.1E-03	1.0E-01	49	1,100	9.5E-02	45.68
Cl-36	3.01E+05	2.1E-03	1.0E-01	50	0	1.4E-04	0.07
Cm-243	4.46E-01	2.1E-03	7.8E-02	38	1,100	7.3E-02	35.22
Cm-244	1.81E+01	2.1E-03	6.7E-02	32	1,100	6.3E-02	30.34
Cm-245	8.50E+03	2.1E-03	1.0E-01	50	1,100	9.6E-02	46.05
Cm-247	1.56E+07	2.1E-03	1.0E-01	50	1,100	9.6E-02	46.10
Cm-248	3.48E+05	2.1E-03	1.0E-01	50	1,100	9.6E-02	46.09
Co-60	5.27E+00	2.0E-03	3.1E-02	15	7	3.8E-03	1.87
Cs-135	2.30E+06	2.1E-03	1.0E-01	50	50	2.9E-02	13.86
Cs-137	3.00E+01	2.1E-03	7.9E-02	38	50	2.5E-02	12.13
Eu-152	1.35E+01	2.1E-03	5.9E-02	28	1,100	5.5E-02	26.75
Eu-154	8.59E+00	2.0E-03	4.5E-02	22	1,100	4.2E-02	20.74
Gd-152	1.08E+14	2.1E-03	1.0E-01	50	1,100	9.6E-02	46.03
H-3	1.23E+01	2.1E-03	5.6E-02	27	0	1.4E-04	0.07
I-129	1.57E+07	2.1E-03	1.0E-01	50	0	1.4E-04	0.07
K-40	1.25E+09	2.1E-03	1.0E-01	50	10	6.1E-03	2.91
Nb-93m	1.61E+01	2.1E-03	6.4E-02	31	0	1.4E-04	0.07
Nb-94	2.03E+04	2.1E-03	1.0E-01	50	0	1.4E-04	0.07
Ni-59	7.60E+04	2.1E-03	1.0E-01	50	7	4.3E-03	2.06
Ni-63	1.00E+02	2.1E-03	9.6E-02	46	7	4.3E-03	2.05
Np-237	2.14E+06	2.1E-03	1.0E-01	50	0.6	5.0E-04	0.24
Pa-231	3.28E+04	2.1E-03	1.0E-01	50	0.6	5.0E-04	0.24
Pb-210	2.22E+01	2.1E-03	7.2E-02	35	2,000	7.0E-02	33.60
Pd-107	6.50E+06	2.1E-03	1.0E-01	50	7	4.3E-03	2.06
Pt-193	5.00E+01	2.1E-03	8.8E-02	42	0	1.4E-04	0.07
Pu-238	8.77E+01	2.1E-03	9.4E-02	45	270	7.0E-02	33.72
Pu-239	2.41E+04	2.1E-03	1.0E-01	50	270	7.7E-02	36.68
Pu-240	6.56E+03	2.1E-03	1.0E-01	50	270	7.7E-02	36.65
Pu-241	1.43E+01	2.1E-03	6.0E-02	29	270	4.7E-02	22.92
Pu-242	3.75E+05	2.1E-03	1.0E-01	50	270	7.7E-02	36.69
Pu-244	5.65E-04	2.1E-03	1.0E-01	50	270	7.7E-02	36.69
Ra-226	1.60E+03	2.1E-03	1.0E-01	50	5	3.1E-03	1.49
Ra-228	5.75E+00	2.0E-03	3.3E-02	16	5	2.9E-03	1.41
Se-79	2.95E+05	2.1E-03	1.0E-01	50	1,000	9.5E-02	45.74

Table RAI B-3.1: Soil Build-up Factors for Various Parameters (Continued)

Radionuclide	Half-life (yrs)	SOIL-1 (a)	SOIL-2 (b)	Ratio SOIL-2 to SOIL-1	K_d (mL/g) (c)	SOIL-3 (d)	Ratio SOIL-3 to SOIL-1
Sm-151	9.00E+01	2.1E-03	9.5E-02	45	1,100	8.8E-02	42.12
Sn-126	2.30E+05	2.1E-03	1.0E-01	50	2,000	1.0E-01	47.74
Sr-90	2.89E+01	2.1E-03	7.8E-02	38	5	3.1E-03	1.47
Tc-99	2.11E+05	2.1E-03	1.0E-01	50	0.6	5.0E-04	0.24
Th-229	7.34E+03	2.1E-03	1.0E-01	50	900	9.4E-02	45.26
Th-230	7.54E+04	2.1E-03	1.0E-01	50	900	9.5E-02	45.31
Th-232	2.91E-03	2.1E-03	1.0E-01	50	900	9.5E-02	45.31
U-232	6.89E+01	2.1E-03	9.2E-02	44	200	6.2E-02	29.99
U-233	1.59E+05	2.1E-03	1.0E-01	50	200	6.9E-02	33.22
U-234	2.46E+05	2.1E-03	1.0E-01	50	200	6.9E-02	33.22
U-235	7.04E+08	2.1E-03	1.0E-01	50	200	6.9E-02	33.22
U-236	2.34E+07	2.1E-03	1.0E-01	50	200	6.9E-02	33.22
U-238	4.47E+09	2.1E-03	1.0E-01	50	200	6.9E-02	33.22
Zr-93	1.53E+06	2.1E-03	1.0E-01	50	900	9.5E-02	45.31

(a) SOIL-1 = soil build-up factor assuming 0.5 year build-up with no leaching
(b) SOIL-2 = soil build-up factor assuming 25 years build-up with no leaching
(c) Obtained from SRR-CWDA-2009-00017, Table 4.2-15 (Vadose Zone)
(d) SOIL-3 = soil build-up factor assuming 25 years build-up with leaching

Note that the dose equations provided in the initial response to RAI B-3, and the "ROOT" component of the calculation for radionuclide concentration in vegetables and fodder provided in SRR-CWDA-2009-00017, Section 5.4.1.1, determine radionuclide build-up based on the *SOIL* expression and parameters shown above but with $\lambda_L = 0$.

Dose calculations performed to support responses in this RAI package include the use of this SOIL factor based on 25 years of irrigation with leaching. Peak dose results in Sectors B and I are provided in response to RAI Comment B-2, Table RAI B-2.4.

B-4	**Comment (New):** The soil to plant transfer factors may be too low due to the elimination of the leafy plant component. **Basis:** WSRC-STI-2007-00004 uses soil to plant transfer factors for non-vegetative portions of food crops because local productivity of non-leafy vegetables is expected to be considerably greater than that of leafy vegetables (based on WSRC-RP-91-17). However, the transfer factors for leafy vegetables can be considerably larger than non-leafy vegetables for key radionuclides. For example, the reference most used as a source of transfer factors in the current analysis (PNNL-13421) has a factor of 210 for leafy vegetables and a value of 0.24 for non-leafy vegetables for Tc. At a 13% leafy vegetable fraction, the vegetable pathway dose from Tc would be over 100 times larger with the leafy and non-leafy components calculated separately and then combined compared to assigning all vegetables as non-leafy. In addition, the WSRC-RP-91-17 reference may have underrepresented garden production data due to limited survey response. **Path Forward:** Include the leafy vegetable pathway explicitly in the plant pathway dose calculation. Consider using EPA or NRC references for garden productivity data.

RESPONSE B-4:

DOE did not explicitly include the leafy plant transfer factor component in the SDF PA dose calculation because leafy vegetables represented only 5% of the total vegetable production in the area surrounding the SRS, and were considered negligible to the total vegetable production. [WSRC-RP-91-17] However, DOE concurs that the transfer factors for leafy vegetables can be considerably larger than transfer factors for non-leafy vegetables for some radionuclides.

To support the response to this RAI, DOE performed a sensitivity analysis to ascertain the impact of revised transfer factors. The transfer factors for soil-to-plant, feed-to-milk, feed-to-beef, and water-to-fish provided in SRR-CWDA-2009-00017, Table 4.6-1 have been updated for use in responses to this RAI package. Table RAI B-2.1 in the response to RAI B-2 provides the updated transfer factors and the parameters used in the PA. The updated transfer factors are based on SRNL-STI-2010-00447. This report, issued after the issuance of Revision 0 of the PA, presents additional details on transfer factors utilized in the past and discussion on transfer factors developed for future use. This report also established a standardized source for transfer factors that represent current data including IAEA-472. Issued in 2010, IAEA-472 provides values for transfer factors in terrestrial and freshwater environments. This report supersedes IAEA-364, which was a key source of data in PNNL-13421, which was used as a primary data source for Revision 0 of the PA. The transfer factors presented in this report assumes that the leafy plant vegetables represent 20% of the total plant production, non-leafy vegetables represent 55% of the total plant production, tubers and root vegetables represent 10% of total plant production, and leguminous vegetables represent 15% of the total vegetable production. If a plant group was not represented in the source documents, it was not included

in the weighted total, but an analog was used instead. Therefore, the leafy component ranges from 20% to 100% of the soil-to-plant transfer factor. For Tc-99, the leafy component represents 44% of the soil-to-plant transfer factor, since a value for the non-leafy vegetables was not provided in the source documents.

With respect to Tc-99, the updated soil-to-plant transfer factor is a factor of 382 greater than the value used in the PA analysis. Dose calculations prepared for responses to this RAI package will use the updated transfer factors presented in Table RAI B-2.1. Peak dose results in Sectors B and I are provided in response to RAI Comment B-2, Table RAI B-2.4.

In addition, the vegetation production yield (referred to as "garden productivity" in the Path Forward) has been updated based on SRNL-STI-2010-00447. The vegetation production yield is used in the "LEAF" component of calculation for radionuclide concentration in vegetation (vegetables and fodder), as shown in SRR-CWDA-2009-00017, Section 5.4.1.1. For dose calculations prepared in support of responses in this RAI package, the vegetation production yield is updated from the PA value of 0.7 kg/m^2 (shown in SRR-CWDA-2009-00017, Table 4.6-5) to 2.2 kg/m^2.

The total peak doses to the MOP provided in Table RAI B-2.4 are less than the values reported in SRR-CWDA-2009-00017, Section 5.5.1.2 and are discussed in the response to RAI Comment B-2. These reductions in dose are attributed to a decrease in the dose from the fish ingestion pathway (caused by a decrease in the water-to-fish transfer factor for Ra-226 as discussed in the response to RAI Comment B-2) and a decrease in the vegetable ingestion pathway (caused by an increase in the vegetation production yield).

B-5	**Comment (New):** The drinking water ingestion rate of 337 L/yr is inconsistent with an average member of the critical group definition. **Basis:** The drinking water ingestion rate is calculated by taking the mean per capita total water ingestion of 1233 mL/day and multiplying by the 75% value from community water. However, this is weighting the critical group member's consumption rate by the type of group the critical group member is in. Given the current site usage and definition of the receptor as a resident farmer, the drinking water consumption rate should be a minimum of 87% of the total water ingestion rate (subtract out the bottled water fraction). Consideration should also be given to adjusting the values for a receptor engaging in a more labor-intensive lifestyles than average in a climate that is warmer than average. **Path Forward:** Modify the drinking water consumption rates to be consistent with the defined receptor and scenario.

RESPONSE B-5:

As discussed in Section 5.6.3.7.1 of the SDF PA, a value of 337 L/yr is used as the nominal water ingestion rate for all members of the public and inadvertent intruder pathway analysis. An EPA drinking water survey (EPA-822-R-00-001) was used to develop the 337 L/yr value. The EPA drinking water survey reports the mean per capita total water ingestion is 1,233 mL/person/d (450 L/yr) when viewed across genders and all age categories with 75% from community water, 13% from bottled water, 10% from other sources (well, spring, and cistern, etc.), and 2% from non identified sources. This yields a mean of 924 mL/person/d (337 L/yr) from community water. In calculating the water ingestion doses, only the individual's primary water source (community water - 75%), was assumed to be contaminated water. The receptor's other water sources such as bottled water (13%), other sources (well, spring, and cistern, etc.; 10%), and non-identified sources (2%) were assumed to be uncontaminated. The fact that the receptor was assumed to drink from a contaminated well does not result in the water ingestion rate being increased by 10% (the other sources, well, spring, and cistern, etc.) because it is expected that any increase would be offset by a decrease in the 75% value due to the receptor drinking "community water" that was not tied to the contaminated well.

In response to this RAI, DOE investigated using an ingestion rate derived from obtaining 87% of the water from a contaminated source (392 L/yr) versus the rate from obtaining 75% of the water from a contaminated source (337 L/yr). The difference between the two values represents an increase of 16% in contaminated water ingestion, and with a linear relationship between the water ingestion rate and the water ingestion dose, the resulting water ingestion dose component would also increase by the same 16%. Using the dose results presented in the response to RAI B-2 for comparison (Table RAI B-2.4), the water ingestion dose for the MOP at the 100-meter well from Sector B and Sector I range between 54% and 77% of the peak dose. If the water ingestion rates were based on obtaining 87% of the water from the well, the peak dose for the member of the public, at the 100-meter well, would increase by

approximately 10% for both Sector B and Sector I. The results are provided in Tables B-5.1 and B-5.2.

The effect of variability in the receptor's water ingestion rate was addressed in the SDF PA through the probabilistic analyses. In the stochastic analyses of the water ingestion rate, the water ingestion rate range was assumed to be as high as 730 L/yr (2 L/d). As presented in SRR-CWDA-2009-00017, Table 5.6-12, the mean of the peaks for Case A is 4.5 mrem/yr within 10,000 years in the probabilistic analysis, which includes all stochastic parameters including the water ingestion rate.

Table RAI B-5.1: Peak Dose Comparison Based on 75% and 87% of the Water Ingested from the 100-Meter Well for the MOP in Sector B

	Contribution to Total Dose (mrem/yr) at Peak Year (9,980) in the first 10,000 years			
Exposure Pathway	337 L/yr water ingestion rate		392 L/yr water ingestion rate	
Water Ingestion	6.9E-01	77.1%	8.1E-01	79.6%
Vegetable Ingestion	1.1E-01	11.9%	1.1E-01	10.6%
Inhalation	4.6E-02	5.1%	4.6E-02	4.5%
Fish Ingestion	3.5E-02	3.9%	3.8E-02	3.5%
Beef Ingestion	3.9E-03	0.4%	3.9E-03	0.4%
Milk Ingestion	2.8E-03	0.3%	2.8E-03	0.3%
Egg Ingestion	2.4E-03	0.3%	2.4E-03	0.2%
Poultry Ingestion	3.3E-04	<0.1%	3.3E-04	<0.1%
All Other Pathways	8.0E-03	0.9%	8.0E-03	0.8%
Total	*9.0E-01*	*100%*	*1.0E+00*	*100%*

	Contribution to Total Dose (mrem/yr) at Peak Year (15,080) in the first 20,000 years			
Exposure Pathway	337 L/yr water ingestion rate		392 L/yr water ingestion rate	
Water Ingestion	1.3E+00	65.1%	1.5E+00	68.4%
Fish Ingestion	3.7E-01	18.7%	3.7E-01	17.0%
Vegetable Ingestion	2.1E-01	10.4%	2.1E-01	9.4%
Inhalation	5.2E-02	2.6%	5.2E-02	2.3%
Milk Ingestion	2.4E-02	1.2%	2.4E-02	1.1%
Beef Ingestion	1.5E-02	0.8%	1.5E-02	0.7%
Egg Ingestion	1.4E-02	0.7%	1.4E-02	0.6%
Poultry Ingestion	4.4E-04	<0.1%	4.4E-04	<0.1%
All Other Pathways	9.3E-03	0.5%	9.3E-03	0.4%
Total	*2.0E+00*	*100%*	*2.2E+00*	*100%*

Table RAI B-5.2: Peak Dose Comparison Based on 75% and 87% of the Water Ingested from the 100-Meter Well for the MOP in Sector I

	Contribution to Total Dose (mrem/yr) at Peak Year (10,000) in the first 10,000 years			
Exposure Pathway	337 L/yr water ingestion rate		392 L/yr water ingestion rate	
Water Ingestion	5.8E-02	53.9%	6.7E-02	57.6%
Fish Ingestion	3.5E-02	33.1%	3.5E-02	30.5%
Vegetable Ingestion	8.8E-03	8.2%	8.8E-03	7.5%
Inhalation	1.9E-03	1.8%	1.9E-03	1.6%
Milk Ingestion	1.6E-03	1.5%	1.6E-03	1.4%
Beef Ingestion	8.4E-04	0.8%	8.4E-04	0.7%
Egg Ingestion	8.0E-04	0.7%	8.0E-04	0.7%
Poultry Ingestion	1.2E-05	<0.1%	1.2E-05	<0.1%
All Other Pathways	2.9E-05	<0.1%	2.9E-05	<0.1%
Total	*1.1E-01*	*100%*	*1.2E-01*	*100%*

	Contribution to Total Dose (mrem/yr) at Peak Year (15,080) in the first 20,000 years			
Exposure Pathway	337 L/yr water ingestion rate		392 L/yr water ingestion rate	
Water Ingestion	1.4E+00	66.4%	1.6E+00	69.6%
Fish Ingestion	3.7E-01	18.3%	3.7E-01	16.5%
Vegetable Ingestion	2.1E-01	10.0%	2.1E-01	9.1%
Milk Ingestion	5.1E-02	2.5%	5.1E-02	2.2%
Beef Ingestion	2.5E-02	1.2%	2.5E-02	1.1%
Egg Ingestion	2.5E-02	1.2%	2.5E-02	1.1%
Inhalation	7.2E-03	0.4%	7.2E-03	0.3%
Poultry Ingestion	1.4E-04	<0.1%	1.4E-04	<0.1%
All Other Pathways	6.5E-05	<0.1%	6.5E-05	<0.1%
Total	*2.0E+00*	*100%*	*2.3E+00*	*100%*

ALARA Analysis (A)

A-1	**Comment:** Social, economic, and public policy considerations do not appear to have been considered in an analysis of maintaining doses "As Low As is Reasonably Achievable" (ALARA). **DOE Response Discussion:** The response to this RAI states that "the estimated dose pathways evaluated in the PA are well below the performance objectives; therefore, a qualitative assessment of disposal alternatives is justified." NRC staff agrees with the concept that a less detailed ALARA is required when the predicted doses are low, but NRC staff would like to note that an assessment that includes the concerns raised in other RAIs (e.g., PA-11, PA-13, IN-1, etc.) may result in a higher calculated dose. In addition, the response to this RAI did not include a discussion on the processes that are being used to minimize the inventory that is disposed of at the SDF. A discussion on maintaining the worker dose at levels that are ALARA was also not included. **Path Forward** Provide additional information on the methodology used to minimize the inventory of radionuclides that are sent to the SDF. Also, provide more details on the controls that exist to minimize the dose to the workers.
RESPONSE A-1: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

Clarifying Questions (C)

As mentioned in the Structure of Comments section of this RAI, the staff found the remaining clarifying comment responses, not referred to in the section below, to be acceptable. In addition to referring to one Clarifying Comment from RAI-2009-01, the staff has added two new clarifying comments in RAI-2009-02.

Table: C-0.1: Status of Clarifying Question Comments for RAI-2009-01

Clarifying Question	Status	Clarifying Question	Status
C-1	Acceptable / Omitted	C-13	Acceptable / Omitted
C-2	Acceptable / Omitted	C-14	Acceptable / Omitted
C-3	Acceptable / Omitted	C-15	Acceptable / Omitted
C-4	Clarify / Incomplete	C-16	Acceptable / Omitted
C-5	Acceptable / Omitted	C-17	Acceptable / Omitted
C-6	Acceptable / Omitted	C-18	Acceptable / Omitted
C-7	Acceptable / Omitted	C-19	Acceptable / Omitted
C-8	Clarify / Incomplete	C-20	Acceptable / Omitted
C-9	Acceptable / Omitted	C-21	Acceptable / Omitted
C-10	Acceptable / Omitted	C-22	New
C-11	Acceptable / Omitted	C-23	New
C-12	Acceptable / Omitted		

C-4	**Comment:** Clarify the basis for the selenium K_d of 150 mL/g for old oxidizing conditions. It is not clear from the PA, or the supporting report WSRC-STI-2007-00640, how the value was selected. Clarify whether the evaluation considered the presence in solution of the selenium as selenate, which is potentially less sorptive than selenite. **DOE Response Discussion:** The DOE discussed site-specific batch experiments that showed selenium K_d values ranging from 29.7 to 78.5 mL/g. These experiments were discounted in favor of literature values due to the aqueous selenium concentrations being near the detection limits. The basis for the selenium K_d of 150 mL/g for old oxidizing conditions relied on the values reported in "Sorption of Selenite and Selenate to Cement Materials" (Baur and Johnson 2003). DOE stated that selenite is expected to convert to selenate under old oxidizing conditions and that the K_d values for selenate from the report by Baur and Johnson (2003) were between 180 and 380 mL/g. DOE further stated that as cementitious materials degrade, the selenium sorption constants (K_d = 1041 mL/g) approach that of the sediment. Selenium sorption was stated as being very high due to the ubiquitous presence of iron oxides and low pH of the sediment. The K_d values of 180 and 380 mL/g reported in "Sorption of Selenite and Selenate to Cement Materials" were for selenite, not selenate. Baur and Johnson (2003) reported no significant update of selenate with calcium-silicate-hydrate (C-S-H) and only limited sorption with ettringite. Furthermore, it is not clear why the sorption coefficient for selenium would approach that of sediment as cementitious materials degrade. The chemistry of degraded cementitious material would not be expected to have the same chemical properties as sediment (high iron content and low pH), which is responsible for the high sorption coefficient for selenium. **Path Forward:** Provide support for the selenium K_d of 150 mL/g for old oxidizing conditions or revise the base case K_d value.
RESPONSE C-4: Response will be provided in SRR-CWDA-2011-00044, Revision 1.	

C-8	**Comment:** For benchmarking cases B-E (Sections 5.6.2.3.5 though 5.6.2.3.8), the PA compares the doses predicted based on the PORFLOW model and post-benchmarking GoldSim model resulting from "all modeled radionuclides". Clarify whether the term "all modeled radionuclides" in this context refers to the original list of radionuclides included in the PORFLOW model or a smaller list of radionuclides modeled during the benchmarking effort. **DOE Response Discussion:** The response to this clarifying comment only addressed the radionuclides included in the Case A PORFLOW and the GoldSim calculations. The radionuclides included in the PORFLOW calculations for Cases B-E were not discussed. **Path Forward:** Provide a list of the radionuclides provided in the PORFLOW calculations for Case B, Case C, Case D, and Case E.

RESPONSE C-8:

For Cases B, C, D, E, and the other cases analyzed in SRR-CWDA-2009-00017, Section 5.6.6, input to the PORFLOW analysis included the following radionuclides: I-129, Np-237, Pu-238, Tc-99, Th-230, U-234, and U-235. The principle dose contributing radionuclides, as identified in SRR-CWDA-2009-00017, Section 5.2.2, were captured in these analyses.

Based upon the modeling input identified above, concentrations for the following radionuclides were computed by PORFLOW:

- Ac-227 (from U-235 decay)
- I-129
- Np-237
- Pa-231 (from U-235 decay)
- Pb-210 (from decay of Th-230, Pu-238, and U-234)
- Pu-238
- Ra-226 (from decay of Th-230, Pu-238, and U-234)
- Tc-99
- Th-229 (from decay of Np-237)
- Th-230 (including decay of Pu-238 and U-234)
- U-233 (from decay of Np-237)
- U-234 (including decay of Pu-238)
- U-235

C-22	**Comment (New):** Figure 4.2-15 in the PA shows the vertical hydraulic conductivity of the lower lateral drainage layer reducing in time to approximately 4E-5 cm/s by 20,000 years. However, the PORFLOW model files indicate that the hydraulic conductivity is only reduced to 4.9E-3 cm/s for all cases. The flux out of the vaults is directly dependent on the infiltration rates. As indicated in IEC-8, the conservatism of the calculations for the hydraulic conductivity of these lateral drainage layers is not clear and according to the PORFLOW model files, it is not clear if these calculations were implemented appropriately. Clarify why different hydraulic conductivity values were implemented in the PORFLOW model.

RESPONSE C-22:

SRR-CWDA-2009-00017 Figure 4.2-15 illustrates the change in the vertical hydraulic conductivity of the sand drainage layer based on the analytical solution presented in Table 22 of SRNL-STI-2009-00115, Revision 1. The values for the hydraulic conductivity used in the PORFLOW runs are provided in Appendix E to SRNL-STI-2009-00115. As shown in Appendix E, the vertical hydraulic conductivity of the sand drainage layer is 4.9E-3 cm/sec during the time period starting at year 15,000 and ending at year 20,000. The difference between the analytical values and the PORFLOW input values is because the PORFLOW time period of 15,000 years to 20,000 years (a period spanning 5,000 years) utilizes the average value spanning that time period (4.9E-3 cm/s) rather than an endpoint value (4E-5 cm/s).

C-23	**Comment (New):** WSRC-STI-2008-00244 discussed the installation quality of the geomembrane as "Good"; however, the HELP model also requires the specification for the placement quality of the geomembrane. The Help model input data in Appendix J of WSRC-STI-2008-00244, listed the geomembrane placement quality as a "2". According to the "HELP User's Guide for Version 3" (Schroeder et al., 1994), an entry of 2, "assumes exceptional contact between geomembrane and adjacent soil that limits drainage rate (typically achievable only in the lab or small field lysimeters)." The basis for selecting the placement quality of the geomembrane should be provided.

RESPONSE C-23:

It appears that there is some confusion related to installation quality of the geomembrane versus placement quality of the geomembrane. Two HELP model geomembrane input parameters, both of which are associated with some aspect of the quality of geomembrane installation (EPA-600-R-94-168a; EPA-600-R-94-168b), are:

- Geomembrane Installation Defects (#/acre)
- Geomembrane Placement Quality

Geomembrane installation defects are defined as geomembrane damage resulting from seaming errors, abrasion, and punctures occurring during installation that result in the generation of holes. The number of installation defects is related to the level of geomembrane installation QA/QC program employed. The HELP model documentation (EPA-600-R-94-168a; EPA-600-R-94-168b) provides a recommended number of installation defects based upon categorization of the QA/QC program employed as excellent, good, fair, or poor.

For the current SDF closure cap design, a HDPE geomembrane quality assurance plan shall be developed and implemented that incorporates visual inspection during installation, wrinkle control, seam field testing, and defect repair, which will be performed in accordance with the approved drawings, plans, and specifications of the final design, which will be produced near the end of the operational period. These SDF closure cap QA/QC requirements represent "good" quality assurance according to EPA-600-R-94-168a and EPA-600-R-94-168b. Therefore, in conformance with HELP model guidance, four installation defects per acre were assumed.

Geomembrane placement quality is related to the degree of contact between the geomembrane and the underlying soil and the potential for lateral flow along the boundary between the two layers. Within the HELP model, there are six geomembrane placement quality designations (i.e., perfect, excellent, good, poor, worst case, geotextile separating geomembrane liner and drainage limiting soil). The cited reference to the HELP User's Guide (EPA-600-R-94-168a) is further elaborated upon in the HELP Engineering Documentation (EPA-600-R-94-168b), which states the following regarding an "excellent" geomembrane placement quality:

> *"Excellent liner contact is achieved under three circumstances. Medium permeability soils and materials are typically cohesionless and therefore generally are able to conform to the geomembrane, providing excellent contact. The second circumstance is for very well prepared low permeability soil layer with exceptional geomembrane placement typically achievable in the laboratory, small lysimeters or small test plots.*

> *The third circumstance is by the use of a geosynthetic clay liner (GCL) adjacent to the geomembrane with a good foundation. The GCL, upon wetting, will swell to fill the gap between the geomembrane and the foundation, providing excellent contact."* [EPA-600-R-94-168b, p. 88]

Consistent with this HELP model guidance and the use of a HDPE geomembrane within the closure cap underlain by a GCL over a bentonite/soil blended upper foundation layer, an "excellent" (HELP model numerical designation 2) geomembrane placement quality designation was utilized for the recommended SDF closure cap. The information provided above associated with both geomembrane installation defects and geomembrane placement quality is also cited in WSRC-STI-2008-00244 Section 5.4.5.

In summary, consistent with HELP model guidance, the assigned number of SDF closure cap geomembrane installation defects was based upon having a good QA/QC program, whereas the selection of the geomembrane placement quality as excellent is based upon having the HDPE underlain by a GCL and specially prepared foundation layer. These two HELP model geomembrane input parameters, while both related to geomembrane installation quality, are distinctly different, and both are implemented within the SDF closure cap HELP modeling according to the appropriate HELP model guidance.

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