Fourth Set of Request for Additional Information Questions for the U.S. Nuclear Regulatory Commission Technical Review Reports Regarding the U.S. Department of Energy 2020 Savannah River Site Saltstone Disposal Facility Performance Assessment

INTRODUCTION:

The U.S. Nuclear Regulatory Commission (NRC) staff identified the following Request for Additional Information (RAI) Questions while drafting Technical Review Reports (TRRs) regarding the U.S. Department of Energy (DOE) 2020 Savannah River Site (SRS) Saltstone Disposal Facility (SDF) Performance Assessment (PA) (NRC's Agencywide Documents Accessand Management System [ADAMS] under Package Accession No. Main Library (ML) ML20190A055).

The staff has organized the review into 14 technical topics: (1) Performance Assessment Methods; (2) Saltstone Performance; (3) Composite Barriers and Drainage Layers; (4) Infiltration and Erosion Control; (5) Disposal StructurePerformance; (6) Far-Field Flow and Transport; (7) Inadvertent Human Intruder; (8) Biosphere; (9) Inventory; (10) Site Stability; (11) Selection of Features, Events, and Processes; (12) Conceptual Models and Future Scenario Uncertainty; (13) Near-Field Flow; and (14) Radionuclide Release. Not all technical topics will be in each set of RAI Questions.

Each NRC RAI Question will be identified by its technical topic and the number of the RAI Question in that technical topic. Each RAI Question contains the requested information, a Basis, and a Path Forward. The Path Forward represents one possible approach to a resolution of the RAI Question. The NRC staff understands that there may be more than one approach to adequately address the technical issue raised in each RAI Question. The adequacy of the DOE Responses to some RAI Questions may depend on the nature of the resolution of other RAI Questions.

This Fourth Set of NRC RAI Questions for the TRRs is related to the following two technical topics: (1) Conceptual Models and Future Scenario Uncertainty; and (2) Infiltration and Erosion Control. In addition, the NRC staff has some Clarifying Comments (CCs) about the 2020 SDF PA.

RAI Questions for the Technical Topic of Conceptual Models and Future Scenario Uncertainty (CM&FSU):

CM&FSU-1

The NRC staff needs additional information about the features, events, and processes (FEPs) and conceptual model related to the projected inhalation dose, including FEP 4.1.05, "Volatiles and Potential for Volatility."

Basis

Table 4.3-1 in the DOE document SRR-CWDA-2018-00006 (ADAMS Accession No. ML18143B265) indicated that the 2020 SDF PA accounts for potential dose from volatile radionuclides in the Central Scenario, with interaction matrix (IM) elements 04.04, "Waste (Decontaminated Salt Solution)" and IM 08.08, "Gaseous Phases." The description of IM 04.04

in Table 3.1-2 of SRR-CWDA-2018-00006 addressed radionuclide removal from salt waste during treatment. From the description of IM 08.08 in the same table, it appears to address volatilization from saltstone itself, but does not include volatilization from contaminated media that a hypothetical person could encounter (e.g., contaminated water). However, there does not appear to be another IM element that addressed radionuclide volatilization from contaminated media a hypothetical person could be in close contact with.

Based on those descriptions, it is not clear to the NRC staff how the 2020 SDF PA accounts for or screens out inhalation of radionuclides that volatilize from water during domestic water use. Consistent with the description of IM 08.08, the SDF Air and Pathway Release (APR) model documented in Section 4.4.7 in the 2020 SDF PA only includes inhalation of radionuclides directly volatilized from the saltstone wasteform and then move in the gas phase through the saltstone wasteform, disposal structures, and closure cap. The APR model does not include radionuclides volatilized from contaminated seepline water or groundwater. Because the NRC staff expects humans to be in closer contact with contaminated water than with the saltstone wasteform, it is not clear to the NRC staff that the projected dose from inhalation of radionuclides volatilized from saltstone and transported through the disposal structures and the closure cap bounds the dose a person could receive from inhalation of radionuclides volatilized from contaminated water, especially in an enclosed environment, such as a shower. Although Figure 4.4-163 in the 2020 SDF PA includes inhalation of water while showering, swimming, or irrigating crops as exposure pathways, Equations 4.4-174 through 4.4-181 and 4.4-194 through 4.4-197 in the 2020 SDF PA, which implement those pathways, appear to be limited to inhalation of radionuclides that form aerosols from water suspended in air and do not include inhalation of volatile radionuclides in the gas phase.

Because FEP 4.1.05 specifically covers volatilized radionuclides, it is not clear to the NRC staff which FEP relates to the inhalation of suspended radionuclides as implemented in Equations 4.4-174 through 4.4-181 and 4.4-194 through 4.4-197 in the 2020 SDF PA. In addition, the conceptual model implemented in those equations is unclear to the NRC staff for the following two reasons.

First, the equations appear to apply an airborne release fraction (ARF) to water that is already present as moisture in air. In the DOE document HNF-SD-WM-TI-707 (ADAMS Accession No. ML13078A177), which the DOE referenced in the calculation of the projected dose from showering in contaminated water in the DOE document SRR-CWDA-2013-00058 (ADAMS Accession No. ML20206L207), the DOE multiplied the moisture content of shower air by an entrainment factor of 0.01 (unitless) to model the fraction of radionuclides that remained in particulate aerosols when the moisture evaporates. In contrast, in the 2020 SDF PA, the DOE multiplied the same moisture content in air by an ARF of 1×10^{-4}, which characterizes the fraction of a liquid that becomes airborne during a free-fall spill. The conceptual basis for multiplying the moisture content in air (i.e., water that is already airborne) by an ARF is unclear to the NRC staff.

Second, the conceptual model in the 2020 SDF PA for the physical state of inhaled radionuclides in shower air is not clear to the NRC staff. The DOE model of suspended radionuclides in shower air in HNF-SD-WM-TI-707 included two contributions: (1) radionuclides in particulate aerosols (as described above); and (2) radionuclides dissolved in water droplets suspended in air (see Section A3.2.2 in HNF-SD-WM-TI-707). Because of the use of the ARF instead of the entrainment factor, it is not clear to the NRC staff whether the DOE intended for

Equations 4.4-174 through 4.4-181 and 4.4-194 through 4.4-197 in the 2020 SDF PA to represent radionuclides in particulate aerosols or in water droplets. In either case, it is not clear to the NRC staff why the equations appear to include only one of the two contributions.

Path Forward
Provide additional information about the conceptual model of the projected dose due to the inhalation of radionuclides while showering, swimming, or irrigating crops, including the physical state or states of the modeled radionuclides (e.g., dissolved, particulate aerosols, gas) and clarify which FEPs apply to each process. Provide a conceptual basis for applying an ARF to an air moisture content (i.e., moisture that is airborne). Provide an analysis to show that the 2020 SDF PA implementation of FEP 4.1.05 does not need to include inhalation of radionuclides volatilized from contaminated water or include those dose pathways in the Central Scenario.

CM&FSU-2
The NRC staff needs additional information on the rational for the DOE screening-out FEP 3.4.11 "Water Table Variability."

Basis
The importance of the flow and transport in the Upper Three Runs Aquifer-Upper Aquifer Zone (UTRA-UAZ) was demonstrated in the DOE document SRNS-RP-2015-00902 (ADAMS Accession No. ML16057A135) and discussed in the May 2018 NRC TRR, *Groundwater Monitoring at and Near the Planned Saltstone Disposal Facility* (ADAMS Accession No. ML18117A494). The thickness of the UTRA-UAZ is dependent on the variability of the water table (i.e., the water table elevation). A lower level may result in the water table sinking into the Tan Clay Confinement Zone (TCCZ) and the UTRA-UAZ above the TCCZ going dry. A higher water table may result in a UTRA-UAZ that dominates groundwater flow and transport.

FEP 3.4.11 "Water Table Variability" in Table 4.1-5 in the 2020 SDF PA was labeled as having been screened-out with the justification that the expected future water table variability was unlikely to impact system performance. The FEP description for this FEP was given as, "Influence of water table fluctuations on oxidation of cementitious materials and radionuclide release from the SDUs."[1] If the influence of FEP 3.4.11 is specific to that description, then it is clear to the NRC staff how the FEP was screened-out. The NRC staff notes that FEP 5.1.06, entitled "Thickness of the Saturated Zone and the Vadose Zone," is too general to capture the specific effects of the thickness of the risk-significant UTRA-UAZ. The NRC staff is not aware of a similar FEP specific to thickness of the UTRA-UAZ.

Path Forward
Provide a technical justification for having screened-out FEP 3.4.11, or provide an additional analysis demonstrating that the FEP "Water Table Variability" should or should not be part of the Central Scenario due to probability and/or consequence.

CM&FSU-3
The NRC staff needs additional information on discrete FEPs that were not included in the original list of FEPs audited.

[1] The NRC uses the terms disposal structures and, when referring to a specific disposal structure, Saltstone Disposal Structure (SDS) #, while the DOE uses the term saltstone disposal units and a DOE saltstone disposal unit includes either one or two disposal structures.

Basis

Although the DOE retained some broad FEPs, the DOE replaced other general FEPs with site-specific, discrete FEPs with the following justification:

> "The FEPs Screening Team identified this FEP as being very broad in scope. Other more discrete FEPs have been identified which more accurately capture the relevant features, events, or processes which should be considered within the PA; as such, this FEP is screened out"

For some general FEPs, the NRC staff is not clear on the DOE rationale for not replacing them with less broad FEPs. For example, the UTRA-UAZ lies above the TCCZ, which makes the TCCZ a risk-significant feature for the reason given above, yet no FEP appears to represent the TCCZ. FEP 2.5.04 is entitled, "Near-Surface Aquifers and Water-Bearing Features" and, although the TCCZ is a water-bearing feature, this FEP is too broad to accurately capture this aquitard. Erosion is another example of a general FEP although discrete, site-specific FEPs such as the different types of erosion (sheet and rill versus gully) or locations of erosion (top versus side versus around the cover) could have been screened-in in place of the general FEP. Such discrete FEPs result in more detailed future scenarios and conceptual models being developed. The closure cap is also not represented by discrete FEPs. Section 4.1.2 in the 2020 SDF PA stated that, for PA modeling, the purpose of the closure cap is to limit the infiltration into the system so that the conceptualization step of the model development process did not require a fully detailed closure cap. It appears to the NRC staff that the same is true for the disposal structures. The purpose of the disposal structure is to limit degradation and radionuclide release into the system. Both the closure cap and the disposal structure are designed to accomplish their goals by various features and process. For example, the cover includes components the impede the water's flow (composite barrier layer), enhance the water's flow (drainage layers), and slow physical damage to the cover (erosion barrier). Capturing those FEPs would allow for the development of future scenarios and conceptual models that better capture and reduce scenario and model uncertainty.

Path Forward

Provide technical justifications for why potentially risk-significant discrete FEPs (i.e., closure cap's erosion barrier, the TCCZ, erosion types) were not screened-in and were not part of the scenario and conceptual model development process. Otherwise, include them in the FEPs audit.

CM&FSU-4

The NRC staff needs additional information on the development of the DOE Alternative Scenarios.

Basis

Section 4.4 in SRR-CWDA-2018-00006 and Section 4.6 in the 2020 SDF PA described the FEPs audit that led to the nine Alternative Modeling Cases that the DOE developed based on the nine Alternative Scenarios. Of the total 345 FEPs that were evaluated during the FEPs analysis, 70 FEPs remained to be addressed after the Central Scenario had been developed, of which 56 FEPs were addressed through the development of ACMs. The NRC staff agrees with the definition of an Alternative Scenario in Table 1.3-1 in SRR-CWDA-2018-00006:

> "An alternative scenario is any scenario that is not the Central Scenario. Usually alternative scenarios will reflect less likely, but still plausible future evolutions of the disposal site. Alternative scenarios may include disruptive events."

The Central Scenario is the expected future evolution of the site; however, specific disruptive FEPs (e.g., disruptive events, processes) can sometimes not be screened-out during the FEPs analysis based the likelihood of occurrence. For example, during the FEPs analysis for the SDF site, the DOE did screen-out igneous activities (e.g., FEPs 6.3.01 and 6.3.01) concluding that igneous activities would be improbable in the next few thousand years. In contrast, the DOE did not screen-out either seismic activities (e.g., FEPs 6.2.01 and 6.2.03) or the effects of subsidence (FEPs 6.2.04). If disruptive events cannot be excluded, then potentially risk-significant scenario uncertainty exists. That uncertainty can be reduced by evaluating alternative scenarios where the disruptive FEPs determine the future evolution of the site and the reviewer assesses the effect on performance. The DOE chose to do something similar by including the screened-in disruptive FEPs into most of their alternative scenarios. The disruptive events included in many of the DOE alternative scenarios listed above were incorporated without consideration of probability (i.e., without weighing the potential events with probabilities), thereby with an assumed probability of 100 percent. The DOE analyzed the following alternative scenarios:

- Early Releases Scenario
- Infiltration Scenario
- Fast Flow Paths through Disposal Structures Scenario
- Fast Flow Paths through Ground Water Scenario
- Soil-Only Cap Scenario
- Stratified Saltstone Scenario
- Perched Water Scenario
- Colloid Transport Scenario
- Inadvertent Human Intruder (IHI) Scenario

Although the DOE described those modeling cases as alternative scenarios, the NRC staff is not certain that some of those alternative scenarios are plausible due to the manner in which they were constructed; thereby hindering the intended exclusion (i.e., screening-out) of disruptive FEPs. The following paragraphs describe alternative scenarios and the disruptive FEPs for which this applies:

FEPs 6.2.01, 6.2.03, and 6.2.04

The alternative scenarios Early Releases, Infiltration, and Fast Flow Paths through disposal structures included the disruptive events seismicity (FEPs 6.2.01 and 6.2.03) and subsidence (FEP 6.2.04). Infiltration and Soil-Only Closure Cap Alternative Scenarios also included the disruptive processes erosion and weathering (FEP 2.6.07) and mass wasting (FEP 2.6.11). Although the alternative scenarios listed above address some of the FEPs in Tables 4.4-1 through 4.4-5 in SRR-CWDA-2018-00006, it is not clear to the NRC staff that the alternative scenarios address all the disruptive FEPs in this paragraph.

A key part of any Alternative Scenario is its plausibility in representing a potential future evolution of the site. Implausible future scenarios generally do not require analysis because the results normally do not help reduce uncertainty. As previously stated, the DOE indicated that it designed the Early Releases, Infiltration, and Fast Flow Paths through disposal structures Alternative Scenarios to address the disruptive events of seismicity and subsidence. Disruptive events are usually significant in their disruptive force causing widespread damage and degradation to multiple natural and engineered barrier components, thereby requiring an alternative to the Central Scenario. While the three alternative scenarios included degradation of specific barriers due to seismic activities, the model did not include the effects of disruptive events on other barriers. For example, the Fast Flow Paths through Disposal Structures Alternative Scenario is probably not plausible for addressing subsidence and seismic activities because the scenario did not include damage to either the closure cap or to the drainage and composite layers above the roof due to subsidence and seismic activities. Consequently, infiltration rates and the saltstone inflow rates remained similar to those of the Compliance Case.

The Infiltration Alternative Scenario included increased and decreased infiltration rates; however, the DOE indicated that it developed those rates to address climate uncertainty and the scenarios did not model other changes to the system that seismic activity would cause (e.g., disrupted composite barriers, disposal structure roofs). A plausible scenario to also address seismic activity would include potential damage to various barriers of the SDF due to earthquakes, which potentially could cause an increase in infiltration. Note that the NRC staff is using the DOE definition of infiltration, which is the water flux out of the closure cap model domain that will be used as the water flux input into the vadose zone model domain. In addition, developing plausible scenarios would entail evaluating the changes to vegetation and surface erosion due to the wetter or drier climate. The Early Releases Alternative Scenario included higher infiltration rates to evaluate risks associated with early releases; but, it is not clear to the NRC staff if the DOE chosen rates were somehow associated with seismic activity. In addition, from the Alternative Scenario description, it appears as if the scenario did not include seismic damage to the drainage and composite layers above the roof and to the roof (i.e., those barrier layers are not part of the closure cap model).

The modeled saltstone inflow rates were probably considerably reduced by those flow barriers due to their undegraded performance, even though the NRC staff expected their performance would be degraded by the postulated seismic activity. One additional Alternative Scenario intended to address seismicity (FEPs 6.2.01 and 6.2.03) was the Fast Flow Paths through Groundwater Alternative Scenario. Table 4.4-5 in SRR-CWDA-2018-00006 described why that Alternative Scenario addressed those FEPs:

> "Significant seismic or subsidence events may disturb groundwater flow patterns in ways which might be approximated by assuming a fast flow path through the vadose zone and the saturated zone."

Although the NRC staff is not familiar with such a phenomenon, the reduction in performance due to potential earthquake damage inflicted on other SDF barriers would likely be greater in magnitude than any such reduction due to the creation of fast flow paths in the unsaturated or saturated zones.

FEPs 2.6.07 and 2.6.11

The Infiltration and Soil-Only Closure Cap Alternative Scenarios were to address erosion and weathering (FEP 2.6.07) and mass wasting (FEP 2.6.11). The Soil-Only Closure Cap Alternative Scenario did not directly include erosion and mass wasting as part of the modeling, although that scenario did include increased infiltration rates to simulate the effects of erosion and mass wasting. However, that scenario did not include damage to the drainage and composite layers above the roof so that the modeled saltstone inflow rates were likely to be less than the infiltration rates due to the ideal performance of those undamaged barriers. In addition, if the closure cap were to consist of soil-only (i.e., without riprap and the erosion barrier), then the 10.5 degree or less side slopes would quickly undergo significant erosion so that the upper perimeters of SDS 7 through SDS 12 (see cross-sections in Figures 3.2-30 and 3.2-31 in the 2020 SDF PA) would eventually be exposed to the surface and its environment. Degradation of the roof and wall would subsequently be accelerated, thereby increasing the threat of uncovering the wasteform itself. If the site evolved in that way, then it is not clear to the NRC staff if the performance objectives in both 10 CFR 61.42 and 10 CFR 61.44 could be met. As with FEPs related to seismic activity, the Infiltration Alternative Scenario included increased and decreased infiltration rates; however, the DOE developed those rates to address climate uncertainty and barriers above the wasteform in the Vadose Zone Flow Model and are likely unaffected by any disruptive FEP. In addition to the increased rate due to climate variability, a plausible scenario to address erosion and mass wasting in the humid climate of the SDF would have required an additional increased inflow rate to the wasteform due to erosion and mass wasting.

FEP 5.1.07
The DOE addressed FEP 5.1.07 entitled “Episodic or Pulse Flow and Release” in two of the Alternative Scenarios: Early Releases and Infiltration. The Early Releases Alternative Scenario assumed a significant rainfall event prior to emplacement of the closure cap resulting in inadvertent early releases. As stated in Section 4.6.1 in the 2020 SDF PA, that scenario provided a non-mechanistic evaluation of multiple FEPs and this rainfall event was not modeled. The DOE also indicated the Infiltration Alternative Scenario would address episodic or pulse flow and release by considering variable infiltration rates. However, neither Alternative Scenario includes episodic (i.e., occurring occasionally, occurring at irregular intervals) or pulse-like infiltration, recharge, or release. Instead, for the Early Releases Scenario, the DOE varied the infiltration rate by step changes, with each step increasing the infiltration rate and lasting hundreds to thousands of years. In the Infiltration Scenario, the DOE held the infiltration rate constant for each realization and varied the infiltration rates between the realizations. Groundwater recharge episodic events are relatively short-term events, such as storms with heavy rainfall, sudden snowmelts, or other events that bring a pulse-like flow of water to the subsurface. Therefore, those two alternative scenarios were not able to address FEP 5.1.07 and that FEP should not be screened-out based on those modeling cases. The erosion barrier within the cover may provide a deterrent against pulse-like flow due to episodic precipitation events as described in Section 4.4.1.4.1 in the 2020 SDF PA; however, it is not clear to the NRC staff if the technical basis supporting the longevity of this barrier is adequate.

The Remaining Alternative Scenarios
In contrast, the Stratified Saltstone, Perched Water, and Colloid Transport Alternative Scenarios did not include either disruptive events or any FEPs capable of changing the evolution of the site. Those modeling efforts are better described as sensitivity cases, more specifically one-on sensitivity cases, where one feature or process, either a stratified saltstone or a perched water layer or colloid transport is included in the Central Scenario and analyzed. Although the interdependencies and interrelationships between the FEPs can be complex, many of the listed FEPs in Tables 4.4-7, 4.4-8, and 4.4-9 in SRR-CWDA-2018-00006 appear to be addressed.

<u>Path Forward</u>
To screen out the disruptive FEPS (i.e., FEPs 6.2.01, 6.2.03, 6.2.04, 2.6.07, 2.6.11) due too low consequence, provide the results from new sensitivity analyses that incorporate all aspects of degradation to all components due to the disruptive FEPs. Alternatively, screen-out the FEPs based on probability, or incorporate the disruptive FEPs in plausible alternative disruptive scenarios. Provide a technical justification for having screened-out FEP 5.1.07 or provide an

additional analysis demonstrating that the FEP entitled “Episodic or Pulse Flow and Release” should or should not be part of the Central Scenario due to its probability, consequence, or both.

CM&FSU-5

The NRC staff needs additional information on the plausibility of an alternative conceptual model involving potentially significant contaminant transport to the 100-meter boundary within the UTRA-UAZ.

Basis

Currently, the DOE has not evaluated a receptor or exposure scenario based on an alternative conceptual model involving potentially significant contaminant transport to the 100-meter boundary within the UTRA-UAZ with the UTRA-UAZ being the hypothetical receptor’s main water source. The NRC staff asked the DOE about the effects of an alternative conceptual model involving potentially significant contaminant transport within the UTRA-UAZ in the NRC staff Request for Supplemental Information (RSI) Comment 8 (ADAMS Accession No. ML20254A003). In that RSI Comment, the NRC staff included the following quotes from the May 2018 NRC TRR:

> “During the May 2014 NRC SDF Onsite Observation Visit (OOV), the NRC staff and the DOE discussed groundwater monitoring results (ADAMS Accession No. ML14199A219). The DOE discussed an alternative conceptual model where contamination from the saltstone disposal structures would be transported not only partially, but primarily above the TCCZ. The Z-Area groundwater characterization study from 2015 showed this to be a valid conceptual model. Not only is flow and transport occurring above the TCCZ for short stretches as simulated by the DOE PORFLOW model (SRR-CWDA-2014-00095; Appendix B), but extends beyond the borders of the Z-Area as sampling from ZDPT 11 and ZDPT 10 has shown.”
>
> “As previously discussed, Wells ZBG 2, ZBG 2D, and ZBG 20D [screened in UTRA-UAZ] have shown nonvolatile gross beta measurements above 30 pCi/L with the highest measurement recorded so far being 158.0 pCi/L, 132.0 pCi/L, and 51.9 pCi/L, respectively. This is in comparison to the groundwater monitoring wells in the UTRA-LAZ including Wells ZBG 2C, ZBG 3, ZBG 4, and ZBG 5 with highest concentration values of 11.5 pCi/L, 4.3 pCi/L, 6.7pCi/L, and 3.6 pCi/L, respectively. The highest measurements for these well samples are all below 15 pCi/L and still have not reached the UTRA-UAZ concentration level of 17 pCi/L measured in 2012.”

Because the SDS 4 plume traveled much quicker in the lateral direction compared to the vertical direction, the majority of future contaminants may also travel much further in a lateral direction than the DOE current conceptual model allows. Further, in the NRC staff Second Set of Request for Additional Information (RAI) Questions for the 2020 SDF PA (ADAMS Accession No. ML21133A296) RAI Far-Field (FF)-1, the NRC staff requested additional information on flow in the UTRA-UAZ that was consistent with the observations from the contaminant plume from SDS 4.

Although the DOE did not construct a new local SDF flow and transport model, the DOE Response to RSI-8 (see DOE document SRR-CWDA-2021-00065 (ADAMS Accession No. ML21217A082) presented an alternative General Separations Area (GSA) groundwater flow model that better represented hydrologic conditions near SDS 4, especially the elevations for

the top and bottom of the TCCZ. In addition, the DOE presented particle tracking results for a refined Z-Area flow field cut from the alternative model. The DOE Responses to both RSI-8 and RAI FF-1 were not sufficient to the NRC staff because neither SRR-CWDA-2021-00065 nor the DOE Response in SRR-CWDA-2021-00072 (ADAMS Accession No. ML21321A087) for RAI FF-1 addressed lateral flow in the UTRA-UAZ.
The Figures 5-4 and 5-6 in the DOE document SRR-CWDA-2018-00036 (ADAMS Accession No. ML20206L238) presented a proposed generalized conceptual model of migration of contamination from SDS 4 to ZBG-2 that is in alignment with NRC staff's generalized conceptual model. That generalized conceptual model shows vertical unit gradient flow in the vadose zone down to the saturated zone and then a predominately lateral flow in the UTRA-UAZ with contaminants gradually flowing downward into the TCCZ. The bottom right-hand pictures in Figure 13 and 14 in SRR-CWDA-2021-00065 showed a different conceptual model where the particle appears to make a straight line to the well ZBG-2, regardless of whether the particle was traveling in the vadose zone or the saturated zone. In addition, the upper right-hand picture of Figure 9 in SRR-CWDA-2021-00065 showed the UTRA-UAZ drying out east of the old well ZBG 2 although water above the TCCZ was recovered east of the Z-Area as reported in SRNS-RP-2015-00902 (ADAMS Accession No. ML16057A135) as well as gross alpha and nonvolatile beta having been measured in water samples from ZDPT 11.

It appears to the NRC staff that the DOE evidence for lateral flow in the UTRA-UAZ is convincing and sufficient for the development of an alternative conceptual model within the Central Scenario. Sufficient water may be available in the UTRA-UAZ to be the main source of water for a hypothetical receptor and the plausibility of such a receptor scenario likely increases with a wetter climate.

<u>Path Forward</u>
Provide a conceptual model that describes how gross alpha and nonvolatile beta were found to be present in the water sample obtained from ZDPT 11 (SRNS-RP-2015-00902). Provide an individual cross-section for each modeled plume with depth for each disposal structure (i.e., SDS 1 through SDS 12) from the water table to the 100-meter boundary. The cross-section representing the modeled plume should show a range of concentrations. In addition, provide a figure or figures showing a line representing each cross-section in X-Y coordinates. From the 1,000-year and 10,000-year peak concentration results for IHI Well 1 through IHI Well 7 (see Table 6.1-2 and 6.1-4 in the 2020 SDF PA), provide the percentage of radionuclides obtained from different hydrogeological units (i.e., UTRA-UAZ, UTRA-LAZ, Gordon Aquifer Unit). For the alternative conceptual model discussed above, provide the results of an analysis of a receptor scenario with the receptor dependent on the UTRA-UAZ as the main water source or demonstrate that the proposed alternative conceptual model is implausible. Or, if the alternative conceptual model is found to be plausible, then demonstrate that the UTRA-UAZ as a main water source for a receptor is unrealistic (e.g., water volume is insufficient at the 100-meter perimeter).

<u>RAI Questions for the Technical Topic of Infiltration and Erosion Control (IEC):</u>

<u>IEC-1</u>
The NRC staff needs additional information regarding the DOE basis for not applying climate change factors to the Probable Maximum Precipitation (PMP) values.

<u>Basis</u>

Section 3 in the DOE document SRR-CWDA-2021-00036 (ADAMS Accession No. ML21160A063) provided recommendations for applying PMP estimates and potential climate change factors for selected water balance parameters that affect the resulting infiltration rates. However, Section 3.6.3 stated that, "… no climate change factor is applied to the PMP values because the use of the 10,000-year PMP value, as opposed to the 1,000-year value, is recommended for analyses to assess uncertainty (per Section 3.5.5) and the difference between the 1,000-year and 10,000-year PMP values is generally on the order of 20 percent to 30 percent for storm durations of less than 1 day (i.e., short-duration, high-intensity storms), which is already roughly equivalent to the potential change to the precipitation rate." Since the DOE results to date have shown deep drainage and infiltration rates as being risk-significant to performance, the NRC staff expects water balance parameter values used to calculate deep drainage to be risk-significant. A wetter long-term climate would naturally be associated with periodic storm events, including a PMP event, differing in intensity from events that occur in the current climate. The DOE rationale for not applying the wetter and drier climate factors to the PMP values is not clear to the NRC staff.

Path Forward
Provide a technical justification as to why the climate change factor was not applied to the PMP values or why PMP values are not affected by potential changes to the climate, or provide a revised analysis that includes a climate change factor applied to the PMP values. Alternatively, provide information demonstrating that difference in climate change adjusted PMP values and unadjusted PMP values is not significant to long-term performance.

IEC-2
The NRC staff needs additional information on the gullying erosion results, specifically for the steeper slopes along the Z-Area hill slopes. In addition, the NRC staff needs additional information regarding the calculations the DOE used to produce Table 7.1-2 and Table 7.1-4 in SRR-CWDA-2021-00036.

Basis
Section 7.1 in SRR-CWDA-2021-00036 described gullying erosion results in Tables 7.1-1 through 7.1-4. The last row of those tables identified the results of Equation 6-1 by stating either "Erosion," indicating that the actual velocities will exceed the permissible velocities, or "No Erosion," indicating that the actual velocities are less than the permissible velocities. The results in those tables showed that the Z-Area hill slopes are at risk of gullying erosion due to the soils along the areas with steeper slopes. Section 7.1 further stated that, "… it is expected that erosion will occur along these hill slopes, but as the head of the gully approaches the hilltop (and the watershed drainage divide), the rate of gullying will likely decrease because the drainage area contributing flow will decrease." However, the rate of headward erosion of any potential gully was not provided by the DOE. The time ranges for when the DOE projects stream heads or knickpoints caused by headward erosion to intersect with the closure cap would be important because the accumulation of runoff from preceding surfaces, including the cover, has the potential to continually provide a flow velocity that promotes gullying.

Table 7.1-2 in SRR-CWDA-2021-00036 showed the gullying erosion results using the 1,000-year PMP return period, including the accumulated runoff from preceding surfaces. Table 7.1-4 in that DOE document showed the gullying erosion results using the 10,000-year PMP return period. Although Section 6.1 in that DOE document described the potential channel paths where gullying may occur and Section 6.2 in that DOE document presented the parameters and equations for estimating gullying erosion, the parameter values used to obtain the final values as presented in both Tables 7.1-2 and 7.1-4 are not clear to the NRC staff.

Gullies that form in the adjacent area of the SDF and continue to grow towards the SDF may eventually affect the performance of the closure cap.

Path Forward

Provide the estimated rate of gully erosion or estimated time range when potential stream heads or knickpoints would intersect with the closure cap based on the results from Tables 7.1-2 and 7.1-4 in SRR-CWDA-2021-00036. Alternatively, provide information that such an intersection is not plausible.

In addition, provide the parameter values used in the equations listed in the right column labeled "Notes" of Tables 7.1-2 and 7.1-4 in SRR-CWDA-2021-00036 that resulted in the final numerical values presented in Tables 7.1-2 and 7.1-4 in that DOE document, including the "Elevation change (H_n)."

IEC-3

The NRC staff needs additional information supporting the soil erodibility values in Table 4.2-4 and in Figure 4.2-5 in SRR-CWDA-2021-00036.

Basis

Parameter values assigned to soil types identified in the Z-Area determine if gully-type erosion can occur near the SDF. Gullies that form in the adjacent area of the SDF and continue to grow towards the SDF may eventually affect the performance of the closure cap. Table 4.2-4 in SRR-CWDA-2021-00036 provided erosion properties for soils identified in the Z-Area, specifically the surface K-factor and the depth-weighted K-factor, which are parameters providing a measure of susceptibility of erosion. Surface K-factor values are applicable when the surface soils are undisturbed while the depth-weighted K-factor values are applicable when the surface soils have been disturbed. SDS 1 and SDS 4 are surrounded by soils that have been disturbed due to operations and construction activities and are displayed as such in Figure 4.2-5 in that DOE document. However, the soils around the other (i.e., cylindrical) disposal structures are also disturbed and are not shown as being disturbed in Figure 4.2-5 in that DOE document. As stated in Section 4.2 in SRR-CWDA-2021-00036, "… it is appropriate to assume that the areas now covered by the cylindrical disposal structures and any areas impacted by construction activities should be assigned their respective depth-weighted values for the K-factors rather than the surface value." However, that is not consistent with Figure 4.2-5 in that DOE document, in which large areas that are impacted by construction activities for the cylindrical disposal structures, including areas outside of the Z-Area boundary, are incorrectly represented by undisturbed soils with low susceptibility to erosion.

In addition, the Troup and Lucy sands along the Z-Area hill slopes were also assigned lower K-factor values representing soils with low erosion susceptibility in Figure 4.2-5 in SRR-CWDA-2021-00036. As Section 5.2, "Area A1," in that DOE document pointed out, areas with that type of soils represent the steepest grade in the vicinity, and Area A1 was identified as representing "… the steepest grade in the vicinity." Table 4.2-4 in SRR-CWDA-2021-00036 showed the soils with percent slopes that range from 15 to 40. As documented in the NRC Onsite Observation Visit (OOV) Report (ADAMS Accession No. ML17054C453) for the SDF OOV on January 25, 2017, one gully was identified in that soil type, specifically in Area A1. Although that gully did not appear to be active at the time of the OOV, the soil was clearly disturbed due to the very steep slopes. It is likely that additional surface areas of the Troup and Lucy sands with percent slopes that range from 15 to 40 are disturbed and should be represented in Figure 4.2-5 in

SRR-CWDA-2021-00036 as disturbed. For the formation of gullies, that change in K-factor value, from 0.02 to 0.24, can be significant because the Troup and Lucy sands, including Area A1, are currently given an overall erosion hazard rating of “slight” as seen in Figure 6.1-4 in that DOE document.

Path Forward
Provide a technical basis as to why the areas covered by the Troup and Lucy sands, and also the areas now covered by cylindrical disposal structures and impacted by their construction activities, are not assigned higher soil erodibility values as seen in Figure 4.2-5 in SRR-CWDA-2021-00036, or provide an updated version of Table 4.2-4 and Figure 4.2-5 showing the soil erodibility (K-factor) values. Alternatively, provide information demonstrating that a change in the soil erodibility value (i.e., from undisturbed to disturbed) will not increase erosion by gullying in a risk-significant manner.

IEC-4
The NRC staff needs additional information regarding the erosion hazard ratings in Figure 4.2-7 in SRR-CWDA-2021-00036.

Basis
The qualitative erosion hazard ratings based on soil type in Table 4.2-4 in SRR-CWDA-2021-00036 were graphically depicted in Figure 4.2-7. It is not clear to the NRC staff how the DOE developed those qualitative ratings. In that document, the DOE described that the erosion hazard rating uses the K-factor and other parameters to provide a general assessment of the risks of erosion and the top of page 84 described the erosion hazard rating as an interpretation of erosion hazards based on an analysis of the K-factor, the slope, and the index of rainfall erosivity. While that DOE document described the first two parameters, the index of rainfall erosivity was not discussed. The erosion hazard rating results may be risk-significant because that information is used in Section 6.2 in that DOE document for estimating gullying erosion. Below are examples of why the erosion hazard ratings are not clear to the NRC staff:

- The soil type VeD was presented as a severe erosion hazard; however, pathways of potential erosion paths appear to be unaffected by the presence of seemingly erodible soil type in Figure 6.1-4 in SRR-CWDA-2021-00036. The pathways of erosion paths I and J adhere to soil types that are rated “slight” although there exists a relatively large area of the “severe” soil type VeD in between the two erosion paths (also see Figure 6.1-2 in that DOE document).

- The soil type TuF was presented as a slight erosion hazard; although, in Table 4.2-4 in SRR-CWDA-2021-00036, the DOE assigned that soil type 25 to 40 percent slopes. As discussed in IEC-3 above, it is likely that areas of the soil type TuF are disturbed and have greater soil erodibility than assigned in Section 4 in that DOE document.

- As described in IEC-3 above, at least one gully was observed in the area with the steepest grade (i.e., Area A1 with the soil type TuE/TuF) while no severe erosion was observed in the soil type VeC/VeD.

Path Forward
Provide additional information to support the erosion hazard ratings in Figure 4.2-7 in SRR-CWDA-2021-00036 or provide a revised version of Figure 4.2-7. Alternatively, provide

information demonstrating that the erosion hazard ratings as presented in Figure 4.2-7 in that DOE document are not risk-significant for calculating gullying erosion.

IEC-5
The NRC staff needs additional information supporting the length of erosion paths A through D in Table 6.1-1 in SRR-CWDA-2021-00036.
Basis
Slope is an important parameter for determining the susceptibility of present and future erosion. The DOE estimated potential future path lines of erosion around the Z-Area based on current topography (see Figures 6.1-1 and 6.2-1 in SRR-CWDA-2021-00036). The DOE calculated the average gradient, or slope, of a potential erosion path by dividing the elevation difference between the two endpoints of an erosion path by the straight distance line between those two points. The endpoints of potential erosion paths A, B, C, and D were extended up to the actual river of Upper Three Runs, over the floodplain of that river. It appears to the NRC staff that it is not likely that a water particle moving down the slope of the Z-Area hills will move along that path after it intersects the floodplain. Most floodplains are formed by deposition on the inside of river meanders and by overbank flow and lack the gradient to move along the DOE suggested erosion path. The endpoints of the potential erosion paths should end and start where potential erosion could actually occur. The average gradient in Table 6.1-1 in that DOE document would then become steeper for erosion paths A through D.

Path Forward
Provide a technical basis for why the potential erosion paths A through D should extend across the Upper Three Runs floodplain or revise the distance between the two endpoints so as not to include the floodplain. Alternatively, provide information demonstrating that either option is not risk-significant for gullying erosion.

IEC-6
The NRC staff needs additional information on how the surface water runoff will be controlled or managed in the Z-Area.

Basis
Based on the uncertainty analysis results from the DOE document SRR-CWDA-2021-00040 (ADAMS Accession No. ML21160A064), the NRC staff determined the following general insight: There is a wide range of variability in the estimated infiltration rates, indicating that there is significant uncertainty associated with the long-term performance of the SDF closure cap. In that DOE document, the DOE stated that, “Until these parameters may be further refined, the uncertainty analysis results in Section 6.1 indicate that a wide range of infiltration rates could be considered for future SDF PA modeling.” Significant uncertainty in infiltration and deep drainage rates implies that significant uncertainty is also associated with the runoff rates. In SRR-CWDA-2021-00036, the DOE provided very useful analyses and information to obtain a better overview and understanding of the potential range of erosion outcomes at the SDF and the Z-Area. However, the uncertainty associated with future gullying and erosion remains large. Many of the parameters used for estimating gullying and sheet/rill erosion have large uncertainties, and the erosion hazard rating is a qualitative analysis. The erosion analysis results in Section 7 in SRR-CWDA-2021-00036 indicated that gully erosion on the Z-Area hill slopes is plausible, although DOE maintained in Section 6.1 in that DOE document that it was unlikely to occur in the future for the following four main reasons.

First, the DOE expected that gully erosion was unlikely to occur in the future because of the protective effects of riprap. In SRR-CWDA-2021-00036, the DOE stated:

> "While some gullying erosion is possible over very long time periods, the side slopes of the closure caps will be armored with riprap (i.e., larger stones able to withstand runoff flow), which will be sized appropriately to protect the closure caps from the effects of long-term erosion."

The NRC staff expects that this could be true for the side slopes of the closure caps; however, the DOE has not indicated to the NRC staff that it has plans for placing riprap on the hill slopes of the Z-Area.

Second, the DOE expected that stream heads will not form on the closure cap because of their elevation. In SRR-CWDA-2021-00036 the DOE stated:

> "Further, it is expected that any future stream heads that may form would originate at spring lines (or seeps); such spring lines would, by their nature, only exist at elevations lower than the closure caps. This is because for a spring or seep to form, a sufficient supply of water is needed, and the closer a path comes to a drainage divide, the smaller the contributing drainage area becomes."

However, to the NRC staff that means that the DOE expectation implies that the head of any gully is stationary and contradicts the following statement in Section 6.2 in SRR-CWDA-2021-00036:

> "It is assumed that gullies that form will form via head-cut erosion, meaning that it will develop from the bottom up: cutting into the hill slopes first, then gradually climbing to the closure cap top slopes."

Gullies are characterized by headwalls on the sides; but, grow in length by upstream, headward erosion at the knickpoint, which causes the origin of a stream channel to move back away from the direction of the stream flow, lengthening the stream channel. For the Z-Area, that lengthening could potentially increase up to the riprap of the closure cap side slopes.

Third, the DOE expected that the surface area that contributes to the respective watershed of potential erosion paths will become relatively small so that the water volume and the velocity of the water will be relatively low, limiting its ability to erode the cap. In SRR-CWDA-2021-00036 the DOE stated:

> "The other thing to note is that as these potential paths move uphill, they approach the watershed boundaries (e.g., see Figure 2.4-3). Near these watershed boundaries, the surface area that contributes to the respective watershed is relatively small such that any surface flow from runoff is not expected to accumulate any significant volumes of water near these boundaries. And because the surfaces at and near these watershed boundaries are generally relatively flat, any overland surface flow that does occur is expected to have relatively low velocity. Accordingly, areas that are close to the watershed boundaries are not expected to be affected by gullying erosion."

The NRC staff expects that this is not necessarily true for the future Z-Area because the watershed boundaries will have moved to the surface of the closure caps and the volumetric rate of water from closure cap runoff may be significant, especially if the High Density Polyethylene layer/Geosynthetic Clay Liner composite barriers and lateral sand drainage layers remain intact and perform well.

Fourth, it appears to the NRC staff that the DOE expected gullying will be unlikely because the DOE developed the erosion path lines without consideration for potential differences in length or for potential differences in the rates of long-term erosion. In addition, the DOE expected that localized features could limit gully erosion by deterring or redirecting the possible directions of such erosion. In SRR-CWDA-2021-00036, the DOE stated:

> "Finally, if every one of these hypothetical path lines were assumed to undergo erosion at an equal rate, then the longer path lines would require more time for these erosion paths to form compared to the shorter path lines. However, each of these path lines were developed without consideration for potential differences in length or for potential differences in the rates of long-term erosion (so if such paths do happen to form, some will form more quickly than others). These paths also do not account for more localized features that could deter or redirect the possible directions of such erosion (such as the presence of roads)."

The NRC staff agrees with the DOE that some potential erosion paths may form more quickly than others; however, the DOE has not demonstrated that variation in the timing of hill slope erosion paths will limit hill slope erosion. Regarding the second DOE point about localized features, although the NRC staff agrees that some localized features may limit erosion, other localized features and events may enhance the rate of erosion, such as a sequence of drought, fire, and large rainfall events.

In addition to the NRC staff concerns about the DOE technical bases in the preceding four paragraphs, the NRC staff expects gully formation could occur because gullies exist along the hill slopes of the Upper Three Runs already. Some gullies appear to be inactive, as the previously mentioned gully in Area A1; but, others nearer to the F-Tank Farm are active as observed during the NRC OOV on March 18-19,2019, as documented in the NRC OOV Report (ADAMS Accession No. ML19143A084). The photographs in the DOE document SRR-CWDA-2019-00040 (ADAMS Accession No. ML19116A225) clearly showed active gully formation along the hill slopes of the Upper Three Runs(e.g., photographs on pages 45-59, 81, and 86-87 SRR-CWDA-2019-00040). Although those gullies are further downstream from the Z-Area, the terrain and vegetation are similar and may be indicative of what may happen at the Z-Area under different climatic conditions.

Due to the significant uncertainty associated with estimating long-term infiltration rates through the SDF closure caps, and therefore with the runoff rates from the closure caps, it is unclear to the NRC staff how the DOE plans to safely managing higher volumetric runoff rates towards the McQueen Branch or the Upper Three Runs and avoid the possibility of headward erosion reaching the base of the closure caps and potentially affecting performance.

<u>Path Forward</u>
Provide a plan or a timeline for creating a plan for safely controlling runoff and surface water from the closure caps down to the streams bordering the Z-Area. Alternatively, provide information demonstrating that it is not plausible for wetter-climate runoff and surface water to create erosional features that will affect the performance of the closure cap.

<u>IEC-7</u>
The NRC staff needs additional information regarding the application of modified rooting depths as described in the DOE document SRR-CWDA-2021-00081(ADAMS Accession No. ML21279A321).

Basis
Section 4.2 in SRR-CWDA-2021-00081 described the application of modified rooting depths after an error was discovered for the “complete erosion” case in the percolation model described in Section 4 in SRR-CWDA-2021-00040. For the “no erosion” cases, the full 91 centimeters (cm) [36 inches (in)] of the topsoil and backfill above the erosion barrier are available for root growth and therefore transpiration. For the “complete erosion” cases, the DOE assumed that those 91 cm [36 in] have eroded away and are no longer available for roots to grow in. In addition, Section 4.2 in SRR-CWDA-2021-00081 included that a maximum root depth was applied based on the assumption that the top of erosion barrier would limit root penetrations (i.e., no root growth or transpiration was to be modeled in the erosion barrier or deeper). The error consisted of nodes representing the full depth of the soil profile being set to simulate roots and the associated transpiration process (i.e., active rooting depth did not stop at the top of the erosion barrier, but rather at the bottom of the profile).

The DOE modified the “complete erosion” cases by assuming that any remaining vegetation would penetrate partially into the erosion barrier. The DOE chose the prairie junegrass since it had the shallowest rooting depth (i.e., a mean rooting depth of 11.4 cm [4.5 in]) of all the different grasses that were evaluated. The DOE then modified the “complete erosion” cases to apply a rooting depth of 11.7 cm [4.6 in] because that value corresponded to the closest node depth to the prairie junegrass’s mean rooting depth. The top 12 model nodes of the 42 nodes representing the soil profile were then set to simulate transpiration. Therefore, the 12 nodes must represent the topsoil, upper backfill, and the upper 11.7 cm [4.6 in] of the one-foot erosion barrier. The remaining 30 nodes would then represent the rest of the model which included the lower part of the erosion barrier, middle backfill, upper lateral drainage layer, and the composite barrier layer.

It is not clear to the NRC staff why 10 nodes would represent less than half of the erosion barrier because the first two nodes of the 12 root-representing nodes were assigned to the topsoil and the upper backfill, as described in Section 4.1 in SRR-CWDA-2021-00081. In addition, it is unclear to the NRC staff whether the 12 root-representing nodes go deeper than the bottom of the erosion barrier and extend into the middle barrier because Table 3.2-8 in the DOE document SRR-CWDA-2019-00001 (ADAMS Accession No. ML 20190A056) defined the function of the middle backfill as “providing water storage for the promotion of evapotranspiration (ET) in the event that the topsoil and upper backfill are eroded away; the overlying erosion barrier provides only minimal water storage.” An erosion barrier that provides minimal water storage would easily dry out, and because no puddles are expected to form on a well-functioning closure cap, the ET rate would be expected to be extremely low.

In addition, for the “complete erosion” case, it is unclear to the NRC staff what percent of the area consists of rock and what percentage consists of filling material (for flora to grow in), for the top of the erosion barrier. It is also unclear to the NRC staff whether the DOE expects the vegetation to differ for the various modeled soil thicknesses in Table 4.2-1 in SRR-CWDA-2021-00081 because the water storage available to plants will become less as the soil on top of the erosion barrier becomes thinner, promoting a potential change in the ecological succession. If vegetation receives and transpires less water, then ET rates are likely to decrease so that surface infiltration and deep drainage rates into the closure caps will increase.

Path Forward
Provide a conceptual model or narrative of the expected ecological succession as the soil containing water storage becomes less thick. Alternately, provide the technical basis as to why

there is no change in the ecological succession and therefore no change in the ET per unit area. For revised "complete erosion" cases, provide a clarification of which layer each of the 42 vertical nodes is associated with. In addition, indicate whether transpiration is being simulated in the lower half of the erosion barrier or deeper. Provide the percent of the area consisting of rock versus the percentage area of filling material for the top of the intended erosion barrier.

IEC-8

The NRC staff needs additional information regarding the DOE claim that evaporation rates increase with erosion on the closure caps.

Basis

Section 5 in SRR-CWDA-2021-00081 stated that:

> ". . . the relationship between ET and erosion is nonlinear because even though the transpiration rates decreased with erosion, the evaporation rates increased with erosion. The increased evaporation is partially due to decreased competition for the available water (because there was less transpiration) and because the hydraulic break caused by the erosion barrier limited the ability for the soil to transmit water into deeper soils where it would not be susceptible to evaporation. As a result of this enhanced evaporation, the net effect of erosion on the ET estimates was relatively small."

The NRC staff is not aware of the above-mentioned relationship between evaporation and erosion, and it is unclear to the NRC staff that this relationship can be viewed as a general rule. It also is not clear to the NRC staff how evaporation rates are able to increase because no puddles are expected to form and then evaporate on a well-functioning closure cap and bare soil from which evaporation could occur is unlikely to exist on the closure cap for long due to the amount of rainfall.

The model information that the DOE provided is not sufficient for the NRC staff to determine the interrelationships between precipitation, plant species and root depths, and soil depths and its relationship to evaporation. It is unclear to the NRC staff whether a risk-significant percentage of evaporation (i.e., not including transpiration) is modeled as having its source deeper than the erosion barrier for some or all of the erosion cases. The presentation of model results currently does not allow the NRC staff to determine if that is the case and the DOE would be expected to present ET results in their separate components (i.e., evaporation and transpiration) to determine the percentage of the total evaporation originating from below the erosion barrier.

If a risk-significant percentage of evaporation was projected to occur deeper than the erosion barrier, then the DOE would need to provide a technical basis for the occurrence of that process at that depth. In addition, for the percolation models, it is unclear to the NRC staff whether a mismatch may exist between input and actual rates that could lead the code to erroneously report high evaporation and low transpiration rates. Albright et al. (2010) indicated that daily data are sufficient only if models apply precipitation rates representative of the field condition; that is, hourly or daily input intervals used in unsaturated flow codes produce more reliable results if the allocations, especially precipitation, represent daily filed conditions as closely as possible. Unrealistically high evaporation would remove water from model's water budget that would otherwise be included as part of the runoff, water storage, or deep drainage components. Providing ET as two separate components provides information to gain risk insights into the model's simulated water balance aligning with the conceptual model of water removal from the closure cap.

Path Forward
Provide references that support the DOE claim that evaporation increases as transpiration decreases partially due to decreased competition for the available water. For Table 4.2-1 in SRR-CWDA-2021-00081, provide ET as two separate components (i.e., evaporation, transpiration). For the resulting evaporation component, provide the percentage of evaporation that has its source deeper than the erosion barrier.

IEC-9

The NRC staff needs additional information regarding the differences between the percolation models in the DOE documents SRRA107772-000009 (ADAMS Accession No. ML18170A244) and SRRA162682-000002 (ADAMS Accession No. ML21179C265) and on the potential impacts on the infiltration results.

Basis
In SRR-CWDA-2019-00001, the DOE relied on the percolation model in SRRA107772-000009, entitled *Predicting Long-Term Percolation from the SDF Closure Cap* from 2018 for information related to infiltration and ET rates. In SRR-CWDA-2021-00040, the DOE used a modified version of the percolation model in SRRA162682-000002, entitled *Predicting Long-Term Percolation from the HTF and FTF Closure Caps* from 2020 to help develop its probabilistic SDF closure cap model. There are numerous differences between the two models and some of those differences were discussed in Appendix B in SRR-CWDA-2021-00040, as were errors found in SRRA162682-000002 by the author. However, for the remaining differences that were not discussed in SRR-CWDA-2021-00040, the impact of some of those differences on the percolation results is not clear to the NRC staff. Specifically, the following is unclear to the NRC staff:

- In SRRA107772-000009, the DOE modeled a closure cap with a 3 percent grade surface, while in SRRA162682-000002, the DOE modeled closure caps with 4 percent grade. In SRRA107772-000009, the DOE stated that, “Two-dimensional simulations were considered unnecessary because of the shallow slope (<1.5 percent) of the cover.” while in SRRA162682-000002, the DOE stated that, “Two-dimensional simulations were considered unnecessary because of the shallow slope (≤4.7 percent) of the cover. Isothermal simulations were conducted.” In SRR-CWDA-2021-00040, the DOE stated that, “Note that this approach is one-dimensional. As such, the two-dimensional influences from lateral flow are assumed to be negligible. However, with a 3 percent surface slope, this modeling approach may be underestimating the influence of runoff.”

    - In order not to underestimate the risk-significant runoff component, at what percent slope should the modeling effort switch from a one-dimensional code to a two-dimensional code? SRRA162682-000002 included that isothermal simulations were conducted while it appears that the SDF closure cap modeling had that feature turned off. Is that another difference between the two models and, if yes, then what are the consequences for the percolation output?

    - As mentioned above, there is an assumed one-degree difference between the SDF closure cap and the closure caps of the Tank Farms. For the steeper closure caps of a tank, the modeled runoff was no more than 8 percent of the annual water balance (see Figure 6 in SRRA162682-000002) while for the shallower SDF closure cap, the runoff was considerably higher – no more than 15 percent of annual water balance (see Figure 11 in SRRA107772-000009). The model with modifications to correct the errors found in the percolation model from SRRA162682-000002 did not significantly change those runoff rates (see

Figure 4.3-2 in SRR-CWDA-2021-00040). Why does the shallower-sloped SDF closure cap (3 percent) have almost double the runoff rate than the steeper covers of the Tank Farms (4 percent)?

  - The footnote associated with Table 4.3-2 in SRR-CWDA-2021-00040, stated that, "The sum of runoff, evapotranspiration, and percolation may exceed precipitation because the models assume conditions wherein moisture from previous years is present within the soils." Provide a revision of Table 4.3-2 with an additional column that includes the modeled annual change in water storge so that all water balance components are included.

- For each of the following three differences between the models in SRRA107772-000009 and in SRRA162682-000002, what are the consequences for the percolation output?

  - The saturated hydraulic conductivity of the upper, middle, and lower backfill are an order of magnitude higher for SRRA107772-000009 (see Table 1) than they are for SRRA162682-000002 (see Table 1).

  - The initial matric head assumed throughout the profile for the first day of the first year is an order of magnitude higher for SRRA107772-000009 (see Section 3.3) than they are for SRRA162682-000002 (see Section 3.3).

  - Equation 2 in SRRA107772-000009 includes $\sin\beta$ in the denominator, while Equation 2 in SRRA162682-000002 includes $\tan\beta$, where β is the slope angle for the drainage layer.

Path Forward
Provide information on differences between the percolation models in SRRA107772-000009 and SRRA162682-000002 and potential impacts on the results.

Clarifying Comments (CC) About the DOE 2020 SDF PA from the NRC Staff:

CC-1
The footnote on page 39 in SRR-CWDA-2018-00006 stated that, "Note that while all [disposal structures] are designed and constructed with high quality concrete, lower quality concrete properties may sometimes be assumed for modeling purposes to ensure defensibility." The NRC staff did not find definitions of high- and low-quality concrete in the 2020 SDF PA. Table 6-44 in the DOE document WSRC-STI-2006-00198 (ADAMS Accession No. ML101600380) provided information about the differences between low- and high-quality concrete. Please confirm whether the information in WSRC-STI-2006-00198 applies to the footnote on page 39 in SRR-CWDA-2018-00006. Please provide any update that the DOE has made to the definitions of low- and high-quality concrete since the DOE issued WSCR-STI-2006-00198.

CC-2
Page 138 in SRR-CWDA-2018-00006 indicated that some portion of the waste will be embedded in the vadose zone soil and in the disposal structure concrete walls and floors when running the Early Releases Alternative Scenario model. How much of the total disposal structure waste is in that portion? Is the concentration and ratio of radionuclides the same as in the disposal structure's saltstone?

CC-4
Provide the sensitivity models for FEPs 2.7.06, 3.2.07, and 3.3.07 as described in Table 4.5-1 in SRR-CWDA-2018-00006.

CC-5
There is a difference between Equation 6-5 in SRR-CWDA-2021-00036 (see page 123) and Equation D-4 in the NRC document NUREG-1623 (ADAMS Accession No. ML052720285) (see page D-7). The elevation difference, or H, is not present in Equation 6-5. Please clarify if both equations are correct or the two equations produce different results.

CC-6
In Section B.4 in in SRR-CWDA-2021-00040, the DOE described that decreasing the depths at which transpiration occurs will result in higher percolation rates; however, Section 4.4 in that document appeared to contradict that by describing that, as soil thicknesses decrease over time due to erosion, percolation rates will also decrease. Please clarify the apparent difference between those two DOE statements.

CC-7
In Section 2.3 in SRR-CWDA-2021-00081, the DOE stated that, "Collectively, this data suggests that total ET cannot be estimated by simply adding potential evaporation rates to potential transpiration rates." In Section 2.2 of that DOE document that described UNSAT-H modeling for percolation rates, the DOE stated that, "Collectively, the potential transpiration and the potential evaporation are computed from the potential ET based on a leaf area index." Please clarify how the DOE calculated the potential transpiration and the potential evaporation from the potential ET and the leaf area index.

CC-8
Figures 7.2-1 and 7.2-2 in SRR-CWDA-2021-00036 showed modeled depths of sheet erosion. Section 7.2 described in more detail what was shown in those figures:

> "In this figure, the dashed curves show the minimum value possible based on the minimum fraction of ground covered by vegetation (Fcover = 0) for the uncertainty factor that affects the cover-management factor (CC) discussed by Panagos et al. (2015); the solid curves show the maximum values possible based on the maximum fraction of ground covered by vegetation (Fcover = 1) for this same uncertainty factor."

However, it appears to the NRC staff that the solid curves showed higher surface erosion than the dashed curves when it is likely to be the opposite. A maximum fraction of ground covered by vegetation (Fcover = 1) should reduce the rate of erosion while a minimum fraction of ground covered by vegetation (Fcover = 0) will allow a greater erosion rate to occur. Please clarify the meaning of the dashed and solid lines in Figures 7.2-1 and 7.2-2 in SRR-CWDA-2021-00036 given the inverse relationship expected between the fraction of the ground covered by vegetation and the extent of sheet erosion.

CC-9
For long-term performance of the erosion barrier, please clarify whether the DOE evaluated other trees and flora native to the general surrounding region of the Z-Area in the past and in the present, and potentially native in the future, other than the loblolly pine. Potential natural vegetation types could include beech, sweet gum, magnolia, oak, and pine, including shagbark hickory and longleaf pine, which are known to have relatively long tap roots.

CC-10
For the erosion barrier design, the current DOE plan is to use coarse grained sand to fill in the void spaces between the larger stones. Please indicate the anticipated range of void space widths between the larger stones.

REFERENCES

Albright, W., C. Benson, and W.J. Waugh. *Water Balance Covers for Waste Containment: Principles and Practice*, August 2010. ISBN978784410707

U.S. Department of Energy (DOE), HNF-SD-WM-TI-707, Rev. 3, *Exposure Scenarios and Unit Dose Factors for Hanford Tank Waste Performance Assessments*, July 2003. ML13078A177

____, WSRC-STI-2006-00198, Rev. 0, *Hydraulic Property Data Package for the E-Area and Z-Area Soils, Cementitious Materials, and Waste Zones*, September 2006. ML101600380

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