PDR

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Talking Points for the March 1998 TSPA Technical Exchange

The U.S. Department of Energy (DOE) recently issued the "Total System Performance Assessment-Viability Assessment (TSPA-VA) Methods and Assumptions" report (TRW Environmental Safety Systems Inc., 1997). The NRC staff has performed a limited review of this report for the purpose of providing constructive comments and early feedback to DOE. In general, the staff found this report informative and quite well written. It provided valuable insights to TSPA-VA and will assist staff's effort in reviewing the TSPA-VA.

During its review, the staff has identified a list of issues that needed further clarification. The staff proposes that these issues be discussed during the March 17-19, 1998, TSPA Technical Exchange at CNWRA. As such, these issues are provided here as talking points and are organized by the broad topics to be discussed in the March Technical Exchange. Note that the topics of disruptive events and scenario analysis will not be included in the March Technical Exchange. The issues identified on these topics will be deferred to the Appendix 7 meeting on April 7, 1998, in Las Vegas, NV.

TSPA Approach

1. What tests will DOE use to check the adequacy of the various model abstractions?

2. Four spatial scales crop up in different places in this document (i) site, (ii) mountain, (iii) drift, and (iv) waste package. What are their precise definitions? Are these definitions consistent across various models? How is information transferred across scales?

3. How is consistency of information maintained when it is transferred from one dimensionality to another, e.g., from a 3D site scale unsaturated flow model (i.e., TOUGH2) to 1D columns for mountain scale thermohydrology, to 3D drift scale models (i.e., NUFT)?

4. When response surfaces are used, are these time-dependent (since the overall model appears to be time dependent because of climate change)? Are these scenarios dependent? 0/1

5. How many response surfaces are developed to take into account variability from one WP to another? Since there are thousands of WPs, what method of lumping is used to get a reasonable set? NH16

6. How are the 3D FEHM computer code results for transport in the unsaturated zone (UZ) are combined with the convolution kernels in the saturated zone (SZ)? Can kernels for heterogeneous anisotropic systems be developed? WM-11 102

7. On p.6-81. The base case for the Environmental Impact Statement (EIS) considers a total inventory of 70,000 MTHM, which includes commercial spent fuel, defense HLW and DOE-owned spent fuel. However, Option 1 and Options 2a and 2b include the base case inventory and 100,000 MTHM additional waste forms (for a total of 170,000 MTHM). With such a large increase in the inventory of waste forms, isn't there an associated increase in both overall repository heat generation and radionuclide inventory? Also, what other aspects would this increase in inventory have on releases and doses? It is unclear how the analyses for 170,000 Metric Tones of Heavy Metals (MTHM) of high-level waste (HLW) will be incorporated in the TSPA-VA. Finally, in a related matter, what impact will the 170,000 MTHM option have on the current design and design bases for Yucca Mountain? Although this issue may be beyond the VA and more appropriately be discussed in the context of the EIS, the staff is interested in DOE's preliminary thinking on how it intends to address this issue.

8. In previous interactions, DOE has noted that conducting some type of post-processing (including augmentation) of the results of the expert elicitations it has sponsored may be necessary to obtain specific data/information needed to support the TSPA-VA. Also, it is not clear to the staff what does the result represent when only one or two experts respond to a particular question. As part of the TSPA-VA documentation, how does DOE intend to addresses these issues?

   (In a related matter, DOE has previously indicated that it intends to conduct new elicitations or perhaps repeat earlier elicitations based on lessons-learned from the VA. Where will this information be discussed? In the TSPA-VA or in the LA plan?)

<u>Water Contacting Waste Packages</u>

1. P.4-9 last paragraph. The comment "most of the percolation flux in the rock will continue around the underground drifts and not enter the drift" needs to be supported before it can be accepted. Subsequent TSPA calculations could be biased by this assumption.

2. In figure 4.1-3, p.4-27: DOE makes what appear to be sound arguments against backfill based on the capillary barrier afforded by an open drift under UZ conditions. However, the design option that includes a ceramic drip barrier requires partial backfill to provide rock fall protection for the barrier. If fractures develop in the ceramic drip barrier, backfill may actually increase the likelihood that water will cross the ceramic drip barrier and contact the WP.

3. In section 6.1.6, p.6-11: The tenor of the second to last paragraph suggests that development of the drift-scale seepage model is behind schedule. Will a model be ready for the TSPA-VA?

4. What are the justifications for the treatment of coupled processes in TSPA-VA? Previous NRC guidance (NUREG-1466) on coupling states that DOE will need to defend its position on the degree of coupling it accounts for in its TSPA. Clarification and explanation are needed during the March 1998 TSPA Technical Exchange.

Example 1. P.6-31: "The general TSPA model architecture is based on the ability to decouple system behavior both spatially and by type of process, i.e., it assumes weak feedback spatially and among processes. This assumption is least tenable when applied to the near-field geochemical environment model, which is highly coupled and nonlinear, being influenced by thermal-hydrologic (TH), and multi-component chemistry." A key assumption in the TSPA-VA is that mechanical and chemical changes do not alter hydrologic properties (p.6-22). This assumption is rather severe. DOE recognizes the severity (TRW Environmental Safety Systems Inc., 1997), however, the assumption affects the UZ flow (p.6-6 and p.6-9), UZ thermohydrology (p.6-20), near-field geochemical environment (p.6-31), UZ radionuclide transport (p.6-116), and SZ model abstractions (p.6-139). "Chemical or mechanical changes to the fracture properties influence the resulting gas-phase and liquid-phase flow fields predicted by the models (drift- and mountain-scale), and thereby potentially affect heat and radionuclide transport as well. Although the response of the mountain to these effects will not be fully coupled in the TSPA-VA analyses, simplifications that patch thermal-mechanical and/or thermal-chemical influences into a UZ-TH simulation have been proposed as a series of sensitivity studies" (p.6-20).

Example 2. P.6-17: "The results will provide relative humidity, air mass fraction, and gas-phase flow rate in the drift; temperature of the WP (surface and center); and liquid saturation and temperature of the concrete liner." This comment is stated again on p.6-23, first full paragraph. There is no mention that liquid water flux into the emplacement drift is important to PA in terms of WP failure. This is not consistent with p.6-20 last line "...rate of water dripping into the drifts are also very important to the performance of the EBS. All of this information is dependent on the conceptual flow model assumed in the simulations." Nor is the p.6-17 comment consistent with statements and overheads presented at the near-field/altered zone expert elicitation meeting when the DOE stated that the presence and flux of liquid water will be considered when evaluating the performance of WPs.

Concentration of Radionuclides During Transport

1. In section 4.1.4, p.4-10: DOE's concept that mixing dissolved radionuclides transported through the UZ to the water table with the "significantly greater volumetric flux in the SZ will cause a reduction in the concentration of the dissolved radionuclides" needs to be supported by actual modeling studies. If vertical velocity components at the water table are small this assertion may not be defensible.

2. In section 4.2.5, p.4-15: the concept of radionuclide concentration reduction due to mixing a small flow rate through YM with large SZ flow rates beneath YM is not supported by field data or modeling. This concept implies mechanical mixing at the water table that is much greater than would be encountered in such a hydrogeologic regime. Members of the DOE Saturated Zone Expert Elicitation (SZEE) panel felt that this "mixing zone" model was incorrect and definitely not conservative.

3. In section 6.7.5, p.6-122: A more detailed explanation is needed as to how the particle

tracking routine in FEHM accounts for matrix diffusion.

4. In section 6.7.6, p.6-127: It is not completely clear how adjustment of the fracture/matrix interaction parameter during the sensitivity analysis will address the effects of "microscopic flow geometries...(such as rivulets)."

5. In section 6.8.4, p.6-138: As noted in previous comments the notion of mixing at the water table is not well supported by data or modeling studies. It should also be noted that the SZEE panel did not support the "mixing depth" model.

6. In section 6.8.5, p.6-139: It is not clear that the linear convolution method that will be used to compute SZ transport is valid for radionuclide chain decay.

7. In most cases, some discussion is provided for how transport will be simulated for the different domains of the YM site (EBS, UZ, SZ), but little detail is provided. A sorption isotherm is likely to be used, but little information is provided to identify what the ranges in these parameters will be, how they will be applied, and what radionuclides will be considered. It seems likely that a linear adsorption model will be used. In the absence of other indications, it also seems likely that the sorption coefficient ranges given in TSPA-95 (TRW Environmental Safety Systems Inc., 1995) will be used. If this is the case, the values for the SZ are essentially identical to those given for the UZ, with higher values given for Pu, U, Np, Ra, and Sr. No sorption coefficients are provided in TSPA-95 for EBS materials. One limitation to the TSPA-95 values is that no information is provided on the source of the K_D ranges except reference to a memorandum (Meijer, 1995) and the TSPA-93 discussion (Wilson et al., 1994, Chap. 9).

Waste Package Lifetime

1. It is unclear how the WP degradation models, and related assumptions, will be revised for TSPA-VA and LA. Furthermore, if the design changes to one using substantially different WP materials, the degradation modes of which may be different than those of the materials under current investigation, how will this affect the models and assumptions that are being incorporated into the WAste Package DEGradation (WAPDEG) and Repository Integration Program (RIP) codes?

2. It is unclear whether an assessment of the potentially adverse effects of placing a drip shield over the WP will be discussed in the sensitivity analyses related to TSPA-VA. If DOE proposes to use design options to affect the release of radionuclides, such as the drip shield or ceramic coatings as illustrated on p. 4-27, DOE needs to consider any adverse effects of the use of these design options.

   For example, there is the potential accelerated corrosion of both the WP and drip shield due to the formation of a crevice between the two components. DOE acknowledges that there is a potential for condensation of water between the drip shield and the WP surface (p. 4-6) and that the interception of water via drip shields may affect the "liquid phase conditions" (p. 4-13). However, on p. 6-57, DOE states, "The drip shield configuration will not be considered part of the base case for TSPA-VA, but will be evaluated in the sensitivity cases."

DOE acknowledges that ceramic coating will not be analyzed in the base case design. However, if the sensitivity analyses are performed to consider the effect of ceramic coating, the adverse effects of such coatings also have to be considered. These include: (i) retardation of heat transfer and resulting increased WP temperatures; (ii) effects of crevices between ceramic coating and overpack surface on localized corrosion of the latter; (iii) any adverse effect of the ceramic coating process on the overpack performance (e.g., any thermal treatment to seal pores). This analysis of the performance of ceramic coating should consider possible stress corrosion cracking (SCC) of some of the coating materials. For example, alumina is known to undergo SCC in water.

Rate of Release of Radionuclides

1. The discussion of credit for cladding in chapter 4 is inconsistent and unclear. The model for cladding credit should be discussed during the March 1998 TSPA Technical Exchange.

2. It is unclear what technical bases will be used to demonstrate that high burn-up fuels will meet the 350°C zirconium alloy cladding temperature limit. Furthermore, it is unclear what technical bases will be used to demonstrate that stainless steel clad fuels will not significantly degrade under the imposed zirconium cladding temperature limit.

3. Spent nuclear fuel and glass dissolution models apparently will include dissolution rates, measures of concentrations in solution and in a colloidal phase. Production of alteration layers are to be considered and compared to mineral phases identified at natural analog sites. Ultimate radionuclide release is to be based on response surfaces of geochemical parameters, mainly pH, CO_3^{-2}, and temperature. Few details are provided on how these response surfaces will be generated and bounded.

4. EBS transport issues are apparently to be designed to include colloid transport. Sensitivity analyses will use sorption isotherms to investigate the impact of sorption on EBS transport. The type of isotherm(s) is/are not identified, but it is stated that the ranges in coefficients that will be considered are to include the effects of pH and temperature. Again, detail on how these effects are to be constrained or how they are to be correlated between different radionuclides is not identified. Degrading concrete is discussed as a sorptive material, but details on sorption behavior are not provided.

References:

Meijer, A. 1995. Memo to S.D. Sevougian, June 7, 1995.

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