REQUEST FOR ADDITIONAL INFORMATION (RAI)
Volume 3—Postclosure Chapter 2.2.1.3.6, 2nd Set (Flow Paths in the Unsaturated Zone)
(RAIs 1 through 10)
(DEPARTMENT OF ENERGY'S SAFETY ANALYSIS REPORT SECTIONS 2.3.2, 2.3.3, and 2.3.5)

RAI #1 Calibration Property Sets

Justify the exclusion of the 50th and 90th percentile infiltration prediction calibration property sets from the basis for confidence in site-scale ambient flow model predictions. This information is needed to determine compliance with 10 CFR 63.114(a)(1,2,7).

Basis: SAR Section 2.3.2.5.1 describes confidence building exercises in site-scale unsaturated zone model results using hydrological, thermal, and geochemical observations only for the 10th and 30th percentile calibration property sets. The exercises included: (i) ECRB water potential measurements (SNL, 2007, Section 7.2), (ii) perched water observations in borehole WT-24 (SNL, 2007, Section 7.3), (iii) pneumatic data (SNL, 2007, Section 7.4), (iv) carbon-14 data (SNL, 2007, Section 7.5), and (v) strontium data (SNL, 2007, Section 7.6). Neither the SAR nor the supporting document (which the SAR refers to as SNL 2007a, Section 7) describes validation or confidence building exercises for the 50th and 90th infiltration scenarios.

Reference:

SNL. 2007. UZ Flow Models and Submodels. MDL-NBS-HS-000006 Rev03 AD001. Sandia National Laboratories.

RAI #2 MSTHM Results and the Postclosure Thermal Design

Explain how the temperatures predicted by the Multiscale Thermohydrological Model (MSTHM) results (SAR Section 2.3.5.4.1.3.2) used in TSPA are representative of the thermal response derived from the anticipated range of thermal loading (SAR Section 2.3.5.4.3, and SNL, 2008a, Section 6.4.2). This information is needed to determine compliance with 10 CFR 63.114(a)(2).

Basis: It is not transparent how the temperatures predicted in SNL 2008a (Figures 6-4.2-1 through 6.4.2-15) fit into the range of MSTHM results (SNL, 2008b, Figure 2.3.5-33). The thermohydrologic responses to the selected hottest loading conditions (7- and 3-point segments from the 96/2 emplacement sequence) are compared to the results from two-dimensional and three-dimensional submodels of the MSTHM (SNL, 2008a, Section 6.4.2). The minimum drift wall and waste package temperatures for the 3-point case are below boiling at all times (SNL 2008a, Figures 6.4.2-10(a), 6.4.2-12(a) and 6.4.2-14(a)) for the cases considered in the analysis. This suggests that the lower bound temperatures expected at the repository are lower than those predicted by the MSTHM model (SAR Figure 2.3.5-33). In addition, the fraction of the repository that will have Case 2 (3-point segment) type of waste packages was not found.

It is not clear how much the difference between results from the MSTHM (SNL, 2008b) and results of thermohydrologic response to the design heat load (SAR, Section 2.3.5.4.3, and SNL, 2008a, Section 6.4.2) is caused by the input parameters of heat load, ventilation efficiency, and heat load emplacement strategy. The heat load discussed in SNL (2008a, Section 6.4.2) states that after 100 years the linear heat load is very similar to the heat load used in MSTHM (SNL, 2008b). The readme file associated with this DTN (MO0705SUPPCALC.000) indicates a three-term exponential fit to the average line load for the postclosure thermal reference case is being calculated. It is not clear what heat load (exponential fit or actual heat load) was used to compare the results. The description provided in SNL (2008a) also is not clear about the quantitative impact of ventilation on heat load. Additionally, the heat load used to represent the base case in 3-D Model Analysis of Temperature Range (SNL, 2008a, Section 6.4.2.3) using the DDTH model is not clearly explained.

References:

SNL. 2008a. Postclosure Analysis of the Range of Design Thermal Loadings. ANL–NBS–HS–000057. Rev00 ERD01. Las Vegas, Nevada: Sandia National Laboratories.

SNL. 2008b. Multiscale Thermohydrologic Model. ANL–EBS–MD–000049 Rev03 ADD02. Las Vegas, Nevada: Sandia National Laboratories.

RAI #3 Variability of Capillary Strength Parameter

Explain how the locations for injections tests used for calibration of the seepage model are representative of variability across the repository footprint. This information is needed to determine compliance with 10 CFR 63.114(a)(1,2).

Basis: Ten injection zones along boreholes at several locations (4 for lithophysal and 2 for nonlithophysal rock) in the ESF and ECRB (SAR Table 2.3.3-2) are used to calibrate the ambient seepage model. No discussion is provided for why these locations are representative of the repository rock units, in terms of rock or hydrological properties. For example, fracture characteristics from the detailed line survey are extensively discussed for the conceptual and numerical model in SAR Section 2.3.3.2.3.2, but are not used in placing the injection zones, or locations, into a representative or variability context.

RAI #4 Uniformity Assumption for Capillary Strength Parameter

Explain the basis for assuming uniform capillary strength at the scale of the drift seepage model domain. This information is needed to determine compliance with 10 CFR 63.114(a)(1,2).

Basis: The rationale is not apparent for the uniformity assumption for the capillary strength parameter (BSC, 2004a, Section 5.4). The seepage model is populated with a heterogeneous permeability field, but a single value of capillary strength is derived. Observations of high and low flow zones from Alcove 6 (BSC, 2004b, Section 6.6), however, suggest variability on a short (~1m) length scale. In addition, estimates derived from theoretical and empirical considerations for fracture zones in Niches 3650 and 4788 suggest local variations are greater than three orders of magnitude (BSC, 2004, Section 6.2.2.2, Table 6-9).

References:

BSC. 2004a. Seepage Calibration Model and Seepage Testing Data. MDL-NBS-HS-000004 Rev03 ACN02. Bechtel-SAIC Company, LLC.

BSC. 2004b. In Situ Testing of Field Processes. ANL-NBS-HS-000005 Rev03. Bechtel-SAIC Company, LLC.

RAI #5 Seepage Conceptual Model and Injection Tests

Explain why variability in seepage test results is best explained by capillary diversion and why alternative conceptual models for the injection test observations (e.g., fractures) are not valid. Explain why seepage is not underestimated when using a model based on capillary diversion. This information is needed to determine compliance with 10 CFR 63.114(a)(1,2,3,7).

Basis: SAR Section 2.3.3.2.3.1 describes a conceptualization of seepage based on capillary diversion at the drift wall. In situ seepage tests were performed along boreholes in the ECRB and ESF; some of the tests were selected for calibration of the seepage model. Considering all seepage tests, it often appears that injection rates vary abruptly from one packed interval to the next along the boreholes (BSC 2004, Sections 6.2. 6.6, and 6.11). Instead of capillary diversion, the abrupt changes possibly could be explained by variations in the nature of fractures that intersect the borehole. For example, the potential presence of horizontal fractures, small aperture subvertical fractures, or large aperture subvertical fractures may coincide with packed borehole sections where no water seeps, small amounts seep, or large amounts seep quickly. If the fracture network acted as a continuum on the scale of the injection testing, then the abrupt changes in injection and collected seepage back and forth along a borehole should not be expected.

References:

SNL. 2004. In Situ Testing of Field Processes. ANL-NBS-HS-000005 Rev03. Bechtel-SAIC Company, LLC.

RAI #6 Seepage at Low Flux Conditions

Justify the use of a seepage threshold below which no seepage occurs despite a percolation flux. Explain the basis for the value selected for the seepage threshold. Explain how seepage fraction and release of radionuclides to the unsaturated zone are affected by the value selected for the seepage threshold. This information is needed to determine compliance with 10 CFR 63.114(a)(1,2,3,7).

Basis: BSC (2007) states that values below 0.1 kg/yr per waste package are mainly a result of the interpolation procedure. No further discussion or basis could be found for this value.

It is not clear how changes to the seepage threshold value would affect estimates of seepage fraction. The seepage fraction (SAR Section 2.3.3.2.1) depends on selection of a value for the seepage threshold. Furthermore, selection in TSPA of advective or diffusive algorithms for radionuclide release out of the waste package and through the invert depends, in part, on the seepage threshold value. The basis is not transparent for the threshold value for which the seepage model flux result is small enough to warrant setting the seepage table entry to zero.

Reference:

BSC. 2007. Abstraction of Drift Seepage. MDL-NBS-HS-000019 Rev01 AD001. Bechtel-SAIC Company, LLC.

RAI #7 Water Entering Lithophysae

Explain the apparent discrepancy of the conceptualizations for water entering lithophysae between the (i) seepage model conceptualization of capillary diversion around openings such as drifts, and (ii) use of the laminar layers of mineralization in lithophysae for validation of percolation rates. This information is needed to evaluate compliance with 10 CFR 63.114 (a,b,c,g).

Basis: Seepage into lithophysae would not be expected to occur based on the importance of capillary diversion in the seepage model conceptualization. Lithophysae are small openings compared to drift openings; the former generally being more than an order of magnitude smaller than drift openings. The size and shape of an opening in porous media strongly affects the capillary diversion around that opening. Philip, et al.(1989), which is cited in BSC (2007), showed that spherical is the optimal shape for capillary diversion of water around openings. Consistent with Phillips et al. (1989), small, spherical openings more readily divert water percolating water as compared to large, cylindrical openings. SAR Section 2.3.3.2.3.7.4 describes inferences for seepage from precipitates in lithophysal cavities.

However, DOE suggests that percolation estimates are supported by isotopic dating of laminar layers within secondary mineralization found in fractures and cavities (SAR Section 2.3.2.3.4.4 and SNL, 2007 Section 7.7). This implies percolating water readily entered lithophysae, such that total percolation rates would be reflected in the secondary mineralization.

References:

Philip, J.R., J.H., Knight, and R.T. Waechter. 1989. Unsaturated Seepage and Subterranean Holes: Conspectus, and Exclusion Problem for Circular Cylindrical Cavities. Water Resources Research, 25, (I), 16-28. Washington, D.C.: American Geophysical Union.

BSC. 2007. Abstraction of Drift Seepage. MDL-NBS-HS-000019 Rev01 AD001. Bechtel-SAIC Company, LLC.

SNL. 2007. UZ Flow Models and Submodels. MDL-NBS-HS-000006 Rev03 AD001. Sandia National Laboratories.

RAI #8 Changes in Seeping Environment over a Simulation

Clarify how, or if, the fraction of the repository with liquid flux (seepage fraction) contacting the engineered components changes during a TSPA simulation. Also, if the change in the area of seeping environment is applied to the entire TSPA realization, describe the quantitative change in area for seepage environment when considering in-drift condensation. This information is needed to evaluate compliance with 10 CFR 63.114(a)(1,2,3).

Basis: Waste packages experiencing seepage at any time during a TSPA simulation are marked as being in the seeping environment for the entire simulation (SNL, 2008, Section 6.3.3.1.3). Seeping environment is defined to include areas with dripping (seepage) and areas with in-drift condensation (SAR Section 2.4.2.3.2.1.6). However, it is not clear if this tagging of marking waste packages also pertains to in-drift condensation, seismic ground motion and fault displacement, and igneous intrusion scenarios; i.e., do repository areas affected by in-drift condensation, seismic ground motion, and igneous activity cause a shift from non-seeping environment to a seeping environment for the entire TSPA realization? Also, 20,000- and million-year performance assessment simulations are discussed in the SAR (Section 2.4.2.2.2.2). It is not clear how the rule is applied for 10,000-yr results using the 20,000-yr simulations.

Also, the average quantitative change for the seepage environment (area denoted by seepage fraction plus condensation) is not clearly described when considering the process of in-drift condensation, as compared to seeping environment when not considering this process.

Seepage fractions are reported in the SAR (e.g., Table 2.1-6), but areas affected by condensation are not presented.

Reference:

SNL. 2008. Total System Performance Assessment Model: Analysis for the License Application. MDL-WIS-PA-000005, REV 00, Las Vegas, NV: Sandia National Labs.

RAI #9 Consistency of Percolation Distribution with Water Table Temperature

Explain how water table temperature data (SAR Figure 2.3.2-37) support predictions for the distribution of unsaturated flow reaching the water table. This information is needed to determine compliance with 10 CFR 63.114(a)(1,2,7).

Basis: Depending on the flux rate, percolating water should depress the geothermal gradient in the unsaturated zone, and perturb the temperature at the water table. Zones of high percolation flux should lead to lower water table temperatures compared to zones with lower percolation flux because water entering the unsaturated zone is cooler than water at depth. Thus, the spatial pattern of water table temperatures should reflect the spatial distribution of percolation flux. Temperatures at the water table could reflect the (i) localized and high flux rates predicted by the unsaturated zone model in faults, (ii) low flux reaching the water table below zeolitic rocks, which predominate in the northern half of the repository, or (iii) intermediate fluxes focused by decreasing areal extent of vitric Calico Hills Formation with depth, which predominates in the southern half of the repository.

Interpolations of water table temperature include those presented in the SAR (Figure 2.3.2-37) and SNL, 2008 (Figure 6.3.1-7), and an interpolation based on the data in Sass, et al. (1988).

Reference:

Sass, J.H., A.H. Lachenbruch, W.W. Dudley, Jr., S.S. Priest, and R.J. Munroe. Temperature, Thermal Conductivity, and Heat Flow near Yucca Mountain, Nevada: Some Tectonic and Hydrologic Implications.” U.S. Geological Survey Open File Report 87-649. 1988.

SNL. 2008. Total System Performance Assessment Model/Analysis for the License Application. MDL-WIS-PA-000005 Rev00. Las Vegas, Nevada: Sandia National Laboratories.

RAI #10 Drift Seepage Rates and Fractions of TSPA Modeling Cases

Explain how average seepage rates and fractions vary or do not vary for different TSPA scenarios for the pre-10,000-yr glacial transition and post-10,000-yr climates. Also explain how uncertainties in seepage rates and fractions vary by scenario for the entire repository for the pre-10,000-yr glacial transition and post-10,000-yr climates.

To support the explanations, provide a table of seepage rates in the seeping environments, seepage percentages, and seepage fractions for the glacial transition and post-10,000 year climates. The table should include nominal/early failure, seismic ground motion, seismic fault displacement, and igneous intrusion TSPA-LA modeling cases. The table should list values of repository-wide average and range (e.g., fifth and ninety-fifty percentiles).

This information is needed to determine compliance with 10 CFR 63.114(a)(1,2,7).

Basis: DOE presents a log-log plot (SAR Figure 2.1-5) to illustrate the time dependent seepage rates for nominal and seismic ground motion modeling cases as calculated by TSPA-LA. Four tables in the SAR, 2.1-6 to 2.1-9, provide the seepage fractions for drifts containing the DOE co-disposed high-level wastes and commercial spent nuclear fuel wastes with respect to the aforementioned modeling cases at 10,000 and 1,000,000 years. Example seepage calculations are also provided in SAR 2.3.3.4.2 for intact and collapsed drifts. In the same SAR section, DOE states that '*[r]esults from this calculation are not utilized in the TSPA*.' The cited seepage rates, percentages, and fractions in the example calculations are helpful in demonstrating barrier capabilities and TSPA-LA seepage calculations. However, they are not the final results from TSPA-LA modeling cases that are required to demonstrate compliance.

This request for additional information is related to that for Request for Additional Information (RAI) for Volume 3 (Postclosure), Chapter 2.2.1.3.6 (Unsaturated Zone Flow), Set 1, RAI #5. Whereas averages of the five percolation bins may be provided for Set 1, RAI#5, repository-wide averages and ranges calculated from the thousands of seepage locations are requested in this new RAI.