THE U.S. NUCLEAR REGULATORY COMMISSION OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS REVIEW OF THE U.S. DEPARTMENT OF ENERGY'S KEY TECHNICAL ISSUE AGREEMENT RESPONSE RELATED TO THE POTENTIAL GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN, NEVADA: TOTAL SYSTEM PERFORMANCE ASSESSMENT AND INTEGRATION 3.10

1.0 INTRODUCTION

By letter dated August 12, 2004, the U.S. Department of Energy (DOE) submitted a letter (Ziegler, 2004) with an enclosure (Appendix N of the "Technical Basis Document No.5: In-Drift Chemical Environment") to satisfy the informational needs of a key technical issue (KTI) agreement item pertaining to the uncertainty of the engineered barrier system chemical and physical environment. The letter and enclosure respond to issues raised, and information requested, by the U.S. Nuclear Regulatory Commission (NRC) related to the treatment of uncertainty in a total system performance assessment (TSPA) for the potential repository at Yucca Mountain, Nevada. The specific agreement addressed in this NRC review of the information provided by DOE in the letter and enclosure is Total System Performance Assessment and Integration (TSPAI) 3.10 (Reamer, 2001).

2.0 AGREEMENTS

Wording of the agreement is provided next.

TSPAI.3.10 [1]

"Provide the documentation of the integrated analyses and comprehensive uncertainty analyses related to the Physical and Chemical Environment Abstraction Model (ENG3.1.5).

DOE will provide the documentation of the integrated analyses and comprehensive uncertainty analyses related to the EBS [engineered barrier system] physical and chemical environment in documentation associated with TSPA for any potential license application. The documentation is expected to be available to NRC in FY 2003."

---

[1] ENG3.1.5 in this agreement refers to item 3.1 of NRC integrated subissue ENG3 on quantity and chemistry of water contacting waste packages and waste forms (NRC 2002, Table 1.1-2). This item addresses the NRC concern regarding inconsistencies among reports in the framework set forth for water pathways and related water chemistry calculations, even though their general inputs and outputs were to be defined by *Engineered Barrier System:Physical and Chemical Environment* (Bechtel SAIC Compnay, LLC, 2004a).

3.0 RELEVANCE TO OVERALL PERFORMANCE

The NRC identified that evaluating the range in chemistry of water seeping into the drift and contacting the drip shield and waste package is important for determining corrosion rates of the engineered materials and has high significance to waste isolation (NRC, 2004). The most significant source of uncertainty in determining the chemical environment for corrosion is the range of in-drift water compositions that may result from spatial and temporal variations in seepage water composition, the composition and amount of condensed water formed by cold-trap processes, and the extent of chemical interactions between these waters and engineered and natural materials. Coupled thermal-hydrological-chemical processes occurring in the rocks that overlie the proposed repository will largely determine the quantity and chemistry of water seeping into the drifts. Explicit and comprehensive evaluation of these coupled processes; however, generally requires the construction of reactive transport models. Reactive transport predictions have substantial sources of uncertainty that are difficult to quantify; nevertheless, these uncertainties are constrained by the system characteristics (e.g., relatively homogeneous rock chemistry) and by the well understood dynamics of evaporation (i.e., the chemical divide phenomenon results in a diversity of water compositions evolving to a few brines).

The NRC synthesized existing information to categorize the KTI resolution agreements according to the risk significance of the agreement (NRC, 2003a). In classifying agreements into the three categories (i.e., low-, medium-, and high-risk significant), risk information (i.e., risk insights) was drawn and synthesized using many types of existing quantitative analyses.

Agreement TSPAI.3.10 is related to the treatment of uncertainty for the engineered barrier system chemical and physical environment in the TSPA and relates only to one aspect associated with the chemistry of seepage water. Agreement TSPAI.3.10, which identified that documentation of the integrated analyses and comprehensive uncertainty analyses related to the Physical and Chemical Environmental Abstraction Model was needed, was identified as medium-risk significance (NRC, 2003a).

4.0 RESULTS OF THE NRC REVIEW

Agreement TSPAI.3.10 requested that DOE provide documentation of the integrated analyses and comprehensive uncertainty analyses related to the Physical and Chemical Environment Abstraction Model. This agreement resulted from a staff review of DOE's documentation that is consistent with Section 2.2.1.3.3.2, Review Methods 3 and 4, of the Yucca Mountain Review Plan (NRC, 2003b). The NRC staff review of the response for this agreement also was conducted in accordance with the aforementioned review methods. Review Method 3 includes evaluating DOE assessment of uncertainty and variability in parameters. Review Method 4 includes evaluating the treatment of conceptual model uncertainty in light of the available site characterization data, laboratory experiments, field measurements, natural analog information and process-level modeling studies.

The focus of TSPAI.3.10 was to document: (1) integrated analyses related to the engineered barrier system physical and chemical environment; and (2) comprehensive uncertainty analyses related to the engineered barrier system physical and chemical environment. The DOE response (Ziegler, 2004) identifies that agreement TSPAI.3.10 is also directly related to KTI

Agreement Evolution of the Near-Field Environment (ENFE) 2.07 Additional Information Needed (AIN-1), which addresses the coupled processes that affect the predicted evolution of the in-drift physical and chemical environments. Further DOE indicates that because ENFE.2.07 AIN-1 covers the integrated coupled analyses, the response to TSPAI.3.10 focuses on the treatment of parameter uncertainty analysis as it relates predominantly to the in-drift chemical environment. The requested information for integrated analyses and comprehensive uncertainty analyses related to the Physical and Chemical Environment Abstraction Model is included, or described, in Enclosure 1 (Ziegler, 2004).

Appendix N (Ziegler, 2004) identifies which model reports (Bechtel SAIC Company, LLC, 2004a, b, c, and d) contain the documentation of integrated analyses and summarizes the model abstraction of the in-drift chemical environment for the TSPA for the License Application. The relationship between the three process models: In-Drift Precipitates/Salts Model, (Bechtel SAIC Company, LLC, 2004b); Drift-Scale Coupled Processes Model (Bechtel SAIC Company, LLC, 2004c); and Drift-Scale Coupled Process Abstraction Model (Bechtel SAIC Company, LLC, 2004d) which feed the chemical and environment model (Bechtel SAIC Company, LLC, 2004a) is described. The response sufficiently discusses, via specific examples (e.g., parametric uncertainty and spatial and temporal variability of processes), how parameter uncertainty (e.g., composition of incoming seepage from the drift crown) and spatial and temporal variability (e.g., values of Cl^- and NO_3^- concentrations and of pH) are treated in the physical and chemical environment model. Finally, the enclosure describes the abstraction of evaporative evolution of crown seepage compositions, the abstraction of dust leachate composition, and the abstraction of aqueous compositions from deliquescence of salts in dust.

Regarding comprehensive uncertainty analyses, the response identifies that each model report (Bechtel SAIC Company, LLC, 2004a, b, c, and d) incorporates specific analyses of model uncertainty. DOE indicates that the *Engineered Barrier System: Physical and Chemical Environment* report (Bechtel SAIC Company, LLC, 2004a) provides comprehensive documentation of process model uncertainty, input data uncertainty, and uncertainty propagation into the TSPA. In Enclosure 1 (Ziegler, 2004), DOE indicated the five primary direct inputs to the physical and chemical environment model and how their uncertainties are treated. The basis for not propagating some of the uncertainty (e.g., composition and flux of in-drift gases) is also provided. Key elements associated with the ranges and distributions of uncertainties that were propagated in the TSPA parameter feeds are summarized in Appendix N. One potential problem, which DOE noted, is that model uncertainty ranges for deliquescence relative humidity from the in-drift precipitates/salts model outputs for relative humidity below 60% is problematic (i.e., the in-drift precipitates/salts model is not valid for relative humidity below 60%). Nevertheless, the description of the uncertainty analyses is comprehensive and limitations are clearly identified.

The DOE also provided information on the integrated coupled analyses associated with the physical and chemical environment (Ziegler, 2004) in response to ENFE.2.07 AIN-1. The NRC staff reviewed the information submitted by DOE and, based upon the staff review, the NRC considers agreement ENFE.2.07 complete (Kokajko, 2004).

Based on the NRC review of DOE's response to Agreement TSPAI.3.10 in accordance with methods discussed in the appropriate section of NRC (2003b, Section 2.2.1.3.3.2 Review Methods 3 and 4), NRC found DOE's response, in conjunction with the information provided in response to ENFE.2.07 AIN-1, met the intent of the agreement.

5.0 SUMMARY

NRC staff reviewed DOE's KTI agreement response in an enclosure to a letter dated August 12, 2004, to determine whether any important aspect of Agreements TSPAI.3.10 was excluded from the response. In addition, the NRC staff performed an independent assessment to determine whether the information provided addressed information requested by the agreement. Notwithstanding new information that could raise new questions or comments concerning these agreements, the information provided satisfies the intent of the agreement. On the basis of this review, the NRC staff considers that the information DOE assembled in response to agreement TSPAI.3.10 met the intent of the agreement and no additional information is needed.

6.0 STATUS OF THE AGREEMENTS

Based on the preceding review, NRC staff has no further questions at this time with respect to Agreement TSPAI.3.10. Therefore, the NRC staff considers this agreement closed.

7.0 REFERENCES

Bechtel SAIC Company, LLC. "Engineered Barrier System: Physical and Chemical Environment." ANL-EBS-MD-000033 REV 02, with errata. Las Vegas, Nevada: Bechtel SAIC Company, LLC. 2004a.

Bechtel SAIC Company, LLC. "In-Drift Precipitates/Salts Model." ANL-EBS-MD-000045 REV 01 ICN 01. Las Vegas, Nevada: Bechtel SAIC Company, LLC. 2004b.

Bechtel SAIC Company, LLC. "Drift-Scale Coupled Processes (DST and THC Seepage) Models." MDL-NBS-HS-000001, with errata. Las Vegas, Nevada: Bechtel SAIC Company, LLC. 2004c.

Bechtel SAIC Company, LLC. "Abstraction of Drift-Scale Coupled Processes." MDL-NBS-HS-000018 REV 00, with errata. Las Vegas, Nevada: Bechtel SAIC Company, LLC. 2004d.

Kokajko, L.E. "Pre-Licensing Evaluation of 'Evolution of the Near-Field Environment' ENFE.2.07 [Status: Complete]." Letter (December 30) to J.D. Ziegler DOE. Washington, DC: NRC. 2004.

NRC. "Risk Insights Baseline Report, April 2004." Washington, DC: NRC. 2004. <http://www.nrc.gov/waste/hlw-disposal/reg-initiatives/resolve-key-tech-issues.html#process>

NRC. "Final Staff Response to March 19, 2003, Staff Requirements Memorandum on the Waste Arena Briefing - M030303A." Memorandum to Commission (June 5). Washington, DC: NRC. 2003a. <http://www.nrc.gov/waste/hlw-disposal/reg-initiatives/resolve-key-tech-issues.html#process>

NRC. NUREG–1847, "Yucca Mountain Review Plan—Final Report." Rev. 2. Washington, DC: NRC. 2003b.

NRC. NUREG–1762, “Integrated Issue Resolution Status Report.” Washington, DC: NRC. 2002.

Reamer, C.W. “U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Total System Performance Assessment and Integration (August 6 Through 10, 2001).” Letter (August 23) to S. Brocoum DOE. Washington, DC: NRC. 2001.

Ziegler, J.D. “Transmittal of Appendix N of the *Technical Basis Document No.5: In-Drift Chemical Environment* Addressing Key Technical Issue (KTI) Agreement Related to Total System Performance Assessment and Integration (TSPAI) 3.10, and An Ungrouped KTI Related to Evolution of the Near-Field Environment (ENFE) 2.07 Additional Infomration Need (AIN)-1.” Letter (August 12) to Director, Division of High-Level Waste Repository Safety, NRC. Las Vegas, NV: DOE. 2004.