May 8, 2002

Joseph D. Ziegler, Acting Assistant Manager
Office of Licensing and Regulatory Compliance
U.S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 364629
North Las Vegas, NV 89036-8629

SUBJECT: THERMAL EFFECTS ON FLOW KEY TECHNICAL ISSUE AGREEMENT

Dear Mr. Ziegler:

During a Technical Exchange and Management Meeting held on January 8-9, 2001, the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Energy (DOE) reached agreement on a number of issues within the Thermal Effects on Flow (TEF) Key Technical Issue (KTI). By letter dated January 31, 2002, DOE provided information pertaining to TEF Agreement 2.09. The NRC staff has reviewed this information as it relates to the agreement and the results of the staff's review are enclosed.

In summary, the staff believes the report provided with DOE's letter fulfilled its purpose of developing an approach to evaluate variability and uncertainty in fracture permeability on relevant thermally-affected parameters. The staff agrees with the view expressed in the report that this work represents the first major step in incorporating the influence of drift-scale heterogeneity in the Multiscale Thermohydrologic Model (MSTHM). The NRC will monitor the future implementation of the DOE approach to incorporate the influence of heterogeneity in the MSTHM when it reviews future DOE documents (such as revisions or changes to the MSTHM Analysis Model Report). The NRC believes this agreement does not need to remain open to track the evolution of the MSTHM, therefore, it is listed as "Complete." If you have any questions regarding this letter, please contact Mr. James Andersen of my staff. He can be reached at (301) 415-5717.

Sincerely,

/RA/

Janet Schlueter, Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated
cc: See attached distribution list

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Letter to J. Ziegler from J. Schlueter dated: May 8, 2002

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NRC Review of DOE Documents Pertaining to
Key Technical Issue Agreements

The U.S. Nuclear Regulatory Commission (NRC) goal of issue resolution during the pre-licensing period is to assure that the U.S. Department of Energy (DOE) has assembled enough information on a given issue for NRC to accept a license application for review. Resolution by the NRC staff during pre-licensing does not prevent anyone from raising any issue for NRC consideration during the licensing proceedings. Also, and just as importantly, resolution by the NRC staff during pre-licensing does not prejudge what the NRC staff evaluation of that issue will be after it's licensing review. Issues are resolved by the NRC staff during pre-licensing when the staff has no further questions or comments about how DOE is addressing an issue. Pertinent new information could raise new questions or comments on a previously resolved issue.

This enclosure addresses one NRC/DOE agreement made during the Thermal Effects on Flow (TEF) Technical Exchange and Management Meeting (see NRC letter dated January 26, 2001, which summarized the meeting). By letter dated January 31, 2002, DOE submitted information to address TEF Agreement 2.09. The information submitted for this agreement is discussed below:

1) Thermal Effects on Flow Agreement 2.09

Wording of the Agreement: Provide the Multi-Scale Thermohydrologic Model AMR [Analysis and Model Report], ICN 03. The DOE will provide the Multi-Scale Thermohydrologic Model AMR (ANL-EBS-MD-00049) Rev 00 ICN 03 to the NRC. Expected availability July 2001.

NRC Review: The technical issue underlying TEF Agreement 2.09 is provided in NRC's Revision 3 of the Issue Resolution Status Report (IRSR) for the TEF key technical issue (dated November, 2000). A discussion provided in this IRSR noted that site data indicate that heterogeneity of fracture permeability can range over at least four orders of magnitude within a single geological layer. Therefore, the NRC staff questioned whether DOE's approach of using homogeneous layer properties in a model could adequately represent data variability and uncertainty when fracture permeability data may range over several orders of magnitude within a single geological layer (page 93 of Revision 3 of the TEF IRSR). The NRC staff concluded that DOE's approach needed to be able to evaluate the effect of variability and uncertainty in fracture permeability on relevant thermally-affected parameters such as temperature, humidity and seepage.

By letter dated January 31, 2002, DOE provided the following report as it pertains to this agreement, "Multiscale Thermohydrologic Model", Revision 00, ICN 02. Although the agreement called for DOE to provide version ICN 03 of the subject report, DOE indicated in the transmittal letter they were able to incorporate into version ICN 02 the information needed to address the underlying technical issue (i.e., heterogeneity).

The DOE report describes the thermohydrologic evolution of the near-field environment and engineered barrier subsystem. Relevant to TEF Agreement 2.09, version ICN 02 of the report contains a new section describing results of simulations where intralayer heterogeneity was incorporated in a three-dimensional drift-scale thermohydrolgoic submodel. A discussion of the physics of seepage into an open cavity was also added. The objectives of the new analyses were to evaluate the possibility of preferential flow penetrating the boiling zone and to determine if environmental conditions in the drift would differ when fracture heterogeneity was included in the model. Sensitivity of results to geostatistical properties for fracture hydrologic parameters were also analyzed. The analyses provided in the report are described as the first major step in incorporating the influence of drift-scale heterogeneity in the the Multiscale Thermohydrolgoic Model (MSTHM). The report also describes some revisions to the approach to be used in future calculations.

Fracture heterogeneity is included in the part of the submodel immediately surrounding the drift. Geostatistical properties for fracture hydrologic parameters are based on existing data from the crown of Niche 3650 in the Topopah Springs middle nonlithophysal unit. In general, heterogeneity will increase seepage. However, the model representation of seepage into a cavity precludes seepage at typical percolation rates; there is a threshold that must be surpassed. If local percolation rates caused by heterogeneity never exceed that threshold, then it would appear there is no sensitivity of seepage to heterogeneity. To facilitate the sensitivity analyses, realizations were selected to ensure that seepage into the drift occurred; thus, the report cautions that results from the extreme cases presented should not be construed as the likely case. The use of selected, extreme realizations was deemed necessary because the model typically predicts seepage into drifts only under areas with the highest net infiltration (and percolation) flux, for the upper bound infiltration-flux case.

Initial conclusions presented in the DOE report include:

- Temperatures would not be significantly changed during the boiling or postboiling period as a result of incorporating intralayer heterogeneity of fracture hydrologic properties.

- Relative humidity near the drip shield and evaporation from the drip shield are increased during the postboiling period. However, the magnitude of the increases were deemed to be relatively small.

The DOE report provides an approach to evaluate the effect of variability and uncertainty in fracture permeability on relevant thermally-affected parameters. The NRC staff believes this approach is responsive to the heterogeneity issue underlying TEF Agreement 2.09. Having reviewed this approach for the first time, the NRC staff has the following observations regarding the implementation of that approach.

- The lower lithophysal unit is the primary horizon immediately surrounding the drift. The properties of the middle nonlithophysal unit probably does not adequately represent the lower lithophysal unit. We note that DOE is currently obtaining data from the lower lithophysal unit by doing systematic hydrologic characterization tests in the Enhanced Characterization of Repository Block (ECRB) drift (note that these tests are addressed under the Unsaturated/Saturated Flow under Isothermal Conditions KTI Agreement 4.01). Final analyses to be included with any license application should incorporate data from the lower lithophysal unit.

- Data from the middle nonlithophysal unit were from a relatively small test volume above the crown of Niche 3650, primarily a horizontal test horizon. It is not clear that conclusions about vertical correlation lengths can be made from these data. This observation should be considered when performing geostatistical analyses of data derived from the characterization tests in the ECRB.

- The model incorporates only small scale heterogeneity immediately surrounding the drift. It is possible that intermediate scale heterogeneity may lead to focusing of flow. The effect of intermediate scale heterogeneity should not be discounted without a technical basis.

- Grid resolution is important when representing preferential flow along fractures in a continuum model. It is not clear what grid resolution is adequate to capture such behavior in this case. We note the report cites other modeling studies using grid sizes smaller than those used in this report. Final analyses to be included with any license application should provide a technical basis for selection of grid size.

- The effect of fracture heterogeneity on in-drift conditions was not evaluated for the low-temperature operating mode. Final analyses to be included with any license application should consider all the planned operating modes.

The NRC will monitor the implementation of the DOE approach to incorporate the influence of heterogeneity in the MSTHM when it reviews future DOE documents (such as revisions or changes to the MSTHM AMR). The NRC believes this agreement does not need to remain open to track the future evolution of the MSTHM, therefore, it is listed as "Complete."

Additional Information Needed: None

Status of Agreement: TEF Agreement 2.09 is "Complete."