Department of Energy
Washington, DC 20585

AUG 0 5 2002

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Dr. Michael L. Corradini, Chairman
Nuclear Waste Technical Review Board
2300 Clarendon Boulevard, Suite 1300
Arlington, VA 22201-3367

Dear Dr. Corradini:

This is in response to Dr. Jared Cohen's letter of March 11, 2002, providing the Nuclear Waste Technical Review Board's (Board) perspective on information presented by the U.S. Department of Energy (DOE) at the Board's January 2002 Board Meeting. Based on the presentations at the meeting and previous oversight activities, the Board provided three principal recommendations for DOE to consider in planning future studies at the Yucca Mountain, Nevada site:

- Sustained commitment to continued science and engineering investigations.
- Assimilation of the data and analyses from these investigations into a realistic total system performance assessment.
- Clear and effective communication to decision makers and the public.

The DOE fully concurs with the Board in the importance of these recommendations to the Office of Civilian Radioactive Waste Management program. Our current plans include work that will address all three of your recommendations. Each of these recommendations is discussed in the enclosure to this letter.

The DOE has benefited from the constructive views of the Board. As DOE proceeds to develop a license application, we will look forward to continuing our dialogue with the Board on these and other important issues.

Sincerely,

Dr. Margaret S. Y. Chu, Director
Office of Civilian Radioactive
Waste Management

Enclosure:
U.S. Department of Energy's Responses to Recommendations in the March 11, 2002, Letter from the Nuclear Waste Technical Review Board

Dr. Michael L. Corradini

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Enclosure

U.S. Department of Energy (Department) Responses to Recommendations in the March 11, 2002, Letter from the Nuclear Waste Technical Review Board (Board)

Sustained Commitment to Scientific and Engineering Investigations

The Department believes that the work currently planned and funded to strengthen the technical basis for a potential license application is adequate to request a construction authorization from the U.S. Nuclear Regulatory Commission (NRC). However, the Department is committed to continuing scientific and engineering investigations that will be structured to focus on scientific and technical issues that, if resolved satisfactorially, could bring significant cost reductions and systems enhancements to the implementation of a repository at the site. Such investigations would also be structured to provide increased confidence in the understanding of the physical processes at Yucca Mountain and to improve the defense of long-term projections of site performance. In addition, this effort will evaluate new and emerging technologies for the waste management system. In general, information resulting from these continuing science and technology efforts will not be available for the initial license application, but will be made available throughout the licensing and operational phase of the repository. As such, science and technology related activities not currently underway for the development of the license application can still be undertaken in the continuing scientific and engineering investigations effort, should funding be available.

The Board has identified areas of investigation that could improve understanding of the capability of the site and the engineered system to limit releases to the accessible environment. The Department will be planning scientific and engineering investigations in the areas identified by the Board discussed below and will consider other areas of investigation to enhance our fundamental understanding of system performance.

Hydrologic processes that accelerate or retard radionuclide transport in the unsaturated and saturated zone

The Board notes that some hydrologic processes that may either substantially accelerate or retard radionuclide transport in the unsaturated and saturated zones are poorly understood. The Board's examples are discussed in the following paragraphs.

Current work on transport in the unsaturated and saturated zone is primarily focused on the evaluation, and validation as appropriate, of existing models. Ongoing transport testing work at Busted Butte will be completed, but planned field tests of colloid transport for the unsaturated zone has been cancelled. For the saturated zone, enhancements to the colloid transport model are not planned in the near term. Uncertainty in the colloid transport models for the unsaturated and saturated zones will be evaluated through sensitivity analyses. After submitting information feeds to performance assessment for use in the Total System Performance Assessment (TSPA) for

License Application, the Department will evaluate technical issues related to colloid transport in the unsaturated and saturated zone to determine the need for additional work on colloids both in terms of strengthening the license application case for subsequent updates and improving scientific understanding.

Testing in the bulkheaded section of the Exploratory Studies Facility (ESF), Cross Drift is continuing to focus on evaluating the accumulation and movement of moisture in and around the drift. Available chemical analyses suggest that the source of water in this section of the ESF Cross Drift is condensate rather than seepage. Monitoring will continue to evaluate the source of this moisture.

The predicted consequence of preferential diversion of water around underground openings is the development of a dry-out zone beneath the opening. If a dry-out zone or drift shadow zone of drier conditions exists beneath the drifts at Yucca Mountain, advective and diffusive transport would be greatly reduced in the vicinity of potential points of radionuclide release, leading to longer transport times in the region directly below the waste emplacement drifts. To date, the Department has only partly included the concept in performance assessment calculations of transport in the unsaturated zone. Additional studies to evaluate this concept are likely necessary to take credit for the full shadow zone concept in performance assessment calculations. There is a potential for significant delay in and lowering of peak dose, if diffusive and advective transport rates from the engineered system into the mountain-scale flow system are significantly lowered.

More realistic models of the flow of water in the system after a return to ambient temperature conditions and a more realistic look at the potential for no continuous moisture pathways from the waste form to the invert are additional areas that might lead to increased confidence in system performance. If this work is coupled with drift shadow zone work, it promises to have an impact on both the overall scientific understanding of the system and on calculations of expected dose in the very long term.

Large scale measurement of hydraulic properties of faults

Although there are no large-scale field measurements of hydraulic properties of major geologic faults in the saturated zone at Yucca Mountain, flow in the tuff aquifer is believed to occur in a fracture network that exhibits a preferential north-south strike. Faults mapped at the surface have a similar preferred orientation and are represented implicitly both in the new regional flow model and in the site-scale flow and transport model as zones of enhanced permeability.

It is reasonable to expect variability in fault properties in the saturated zone. The field testing in the area of the Paintbrush Fault penetrated in the well UE25 p-1 indicates that the Paintbrush Fault system at this locality serves as a barrier to flow. However, in other areas, air permeability and flow tests suggest that the fracture and fault zones in Tertiary volcanics exhibit a fairly high permeability relative to the non-faulted rock. The Department believes that the current approach to modeling fault properties in the

saturated zone as zones of enhanced permeability is consistent with the data, however, in some areas of the site this may be conservative. Additional long-term field-testing may lead to a more representative saturated zone flow and transport model.

In the unsaturated zone, direct measurements of fault-specific properties of the Bow Ridge Fault and the Ghost Dance Fault have been conducted using air-injection tests in the ESF. These data suggest that, within the welded units of the Topopah Spring and the Tiva Canyon tuffs, the fractures in the fault zones are more permeable and porous than the fractures in the formation. From these data, it is inferred that faults within the Paintbrush and Calico Hills nonwelded units have higher permeabilities than the adjacent non-faulted rock.

Natural variability in fault properties could result in low permeabilities in portions of these units and retard movement of water. This would lead to slower transport to the water table. Faults are modeled as high permeability structures in the Paintbrush and Calico Hills nonwelded units because there is insufficient data to limit interpretations to a single conceptual model. Long-term testing and analyses may reduce the conservatism in this model and lead to greater performance from the unsaturated zone.

The primary focus of ongoing work on the site-scale saturated zone model is evaluation of this model, and validation as appropriate. The effort is taking into account new data from the Nye County wells and single-well tests at the Alluvial Testing Complex and a comparison of the updated, 2001 United States Geological Survey model with the site-scale saturated zone model. This work will provide the inputs from the site-scale saturated zone model to performance assessment analysts for development of the TSPA for the License Application. The United States Geological Survey is continuing to develop their regional saturated zone model.

Localized Corrosion

The Department has a comprehensive ongoing and planned experimental program to investigate localized corrosion in repository-relevant conditions. The Department has been considering a range of thermal conditions for the repository. At the high end, this range includes thermal conditions in which the surface temperature of the waste package is expected to be less than 180°C. At the low end, this range includes thermal conditions in which the surface temperature of the waste package is expected to be less than 85°C. A key concern for the higher end of the range of thermal conditions is the time at which the surface temperature of the waste package approaches 120°C. That is the temperature at which salts could facilitate formation of moisture on the waste package surface and is the subject of continuing investigations. Continued investigations will focus on the range of susceptibility.

Under projected repository conditions, aqueous solutions at elevated temperatures (>120°C) could occur if chloride salts of calcium ($CaCl_2$) or magnesium ($MgCl_2$) are present. In support of understanding the effect of these hygroscopic salts, atmospheric corrosion studies (i.e. aqueous thin film studies) with deposited $CaCl_2$ are being

conducted at temperatures up to 150°C using a thermogravimetric analyzer and an environmental chamber. The project is addressing the likelihood of $CaCl_2$ and $MgCl_2$ deposition on the waste packages and the quantities that could be expected. Thermodynamic modeling is also underway to understand the compositions of aqueous solutions that could develop under the projected temperature and relative humidity conditions.

Consequences of Igneous Activity

The Department agrees with the Board's assessment that the model proposed by the NRC consultants is overly conservative. The Department has planned additional work to improve the understanding of the consequences of igneous activity, because performance analyses indicate that igneous activity is potentially the largest contributor to the probability-weighted mean annual radioactive dose during the first 10,000 years. An external peer review of the planned work on potential consequences of igneous activity is now underway. The peer review panel is reviewing the current technical basis for the evaluation of the consequences of igneous activity, proposed work to analyze the consequences of igneous activity, and the adequacy of the associated modeling program. They will recommend any augmentations to planned work that would strengthen the technical basis for the evaluation of consequences from igneous activity.

Hydrothermal Upwelling

The Department is pleased that the Board considers the issue of hydrothermal upwelling resolved. As discussed in our letter (Dyer to Cohen, 1/24/02), while the issue of upwelling is closed, we plan to continue the study of secondary minerals to provide additional insights into the understanding of various aspects of flow and transport in the unsaturated and saturated zones.

Assimilation of the data and analyses from these investigations into a realistic total system performance assessment

As we noted at the January 2002 Board Meeting, the TSPA for a potential License Application will, to the extent practicable, include a better treatment of uncertainty than previous iterations of TSPA. The Project is following the approach presented in the 2001 *Uncertainty Analyses and Strategy Letter Report*[1] in developing the TSPA for a potential license application. This is a continuing effort to replace single bounding values with probability distribution values that is highly dependent on the nature and quantity of data available and obtainable. Analyses of the impact of that uncertainty on subsystem and system performance will be included. The Department will continue to assimilate the results of ongoing scientific and engineering investigations into future iterations of the TSPA; however, some conservatism will, of necessity, remain due to the nature of the parameter being considered.

The Department is conducting sensitivity analyses to increase our understanding of the significance of the influence of various components used in the TSPA model. These

analyses include "one-off" neutralization analyses, "one-on" analyses to look at individual barriers, and sequential analyses in which barriers are added one at a time to observe the combined effects of the barriers for gaining insight on individual and combined barrier effects.

[1] Nancy H. Williams. 2001. "Contract Number DE-AC08-01RW12101, *Uncertainty Analyses and Strategy Letter Report*, Revision 00, Activity #SA011481M4." Letter from N. H. Williams (BSC) to S. J. Brocoum (DOE/YMSCO), November 19, 2001, JM:cs-1116010483, with enclosure. ACC: MOL.20020109.0064.

Clear and Effective Communication

The Department agrees that clear and effective communication of technical information and the uncertainties in that information to decision makers and the public is important. The Department has also learned from experience that conveying highly technical information to those same audiences is difficult. The 2002 *Uncertainty Analyses and Strategy Letter Report* provides initial guidance on methods for expressing and communicating uncertainty, including examples of approaches used by other projects to communicate uncertainty. This guidance is being implemented in the development of alternative conceptual models, model abstractions, and parameter uncertainty for the next iteration of the TSPA. The Department is evaluating comments and recommendations from the recent international review of the TSPA, completed to support Site Recommendation, to see how best to communicate highly technical concepts, such as probabilistic calculations and their results and uncertainties, to diverse audiences.