



## Department of Energy

Washington, DC 20585

May 17, 2004

David J. Duquette, Ph.D.  
Acting Chairman  
Nuclear Waste Technical Review Board  
2300 Clarendon Boulevard  
Arlington, VA 22201-3367

Dear Dr. Duquette:

We have received the December 16, 2003, letter from the Nuclear Waste Technical Review Board (Board) providing the Board's initial reactions to the information presented by the U.S. Department of Energy (DOE) at the Board's September 2003 meeting in Amargosa Valley, Nevada. The DOE's responses to the views expressed by the Board are provided in the enclosure to this letter.

The DOE appreciates the Board's continuing review of our activities as we work to complete the analyses and documentation to support the license application for a repository at Yucca Mountain, Nevada, scheduled to be completed in December.

Sincerely,

A handwritten signature in cursive script, appearing to read "M. Chu", written in dark ink.

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

Enclosure



**U.S. Department of Energy Responses to Observations from the Nuclear Waste Technical Review Board on the September 2003 Full Board Meeting**

**Issues Relating to Natural Characteristics of Yucca Mountain**

***1. Igneous scenarios.***

*According to the DOE's estimates, igneous scenarios may dominate the risk to humans from a Yucca Mountain repository. To date, it appears that the DOE intends to pursue only one of the three recommendations made by the Board in its June 30, 2003, letter—study of aeromagnetic anomalies near the Yucca Mountain site. The Board repeats its recommendation that the DOE also conduct modeling studies of compressible fluids and studies of waste package-magma interaction and waste entrainment.*

**Response:**

Further to our letter of October 10, 2003, the Department of Energy (DOE) has evaluated the Board's recommendations to conduct modeling of compressible fluids and studies of waste package-magma interaction and waste entrainment. A model is being developed to bound the behavior of magma flow within a fissure and within a drift. This modeling would also address the likelihood of a "dog-leg" occurring under these bounding flow conditions, and the sustainability of a "dog-leg."

The DOE acknowledges that additional analyses and laboratory and field experiments could lead to a better understanding of the effects of waste package-magma interaction and waste entrainment in magma. It may be possible to gain some insights from experiments and analyses that could be performed over the next couple of years. These analyses and experiments, if conducted, would be used to build confidence in our conclusions and would not be included in our Total System Performance Assessment for the License Application. These analyses and experiments could lead to a reduction in uncertainties associated with waste package-magma interaction.

***2. Enhanced borehole studies.***

*As plans are developed for drilling aeromagnetic anomalies near Yucca Mountain, the Board encourages the DOE to consider additional development of those boreholes as monitoring wells to obtain hydraulic head, water chemistry, and related hydrogeologic data at relatively small additional cost. Additional hydrogeologic data from these areas may resolve differing hypotheses regarding the direction of water flow in the saturated zone and may provide additional information about the ability of the saturated zone to function as a barrier to migration of radioactive materials.*

**Response:**

The DOE agrees that collection of additional hydrologic data is worthy of consideration in those cases where the boreholes are within or adjacent to flow paths from the Yucca Mountain repository to the compliance boundary. The DOE will evaluate the possibility of completing those boreholes as monitoring wells in order to collect hydrologic information if the water table is encountered. The additional cost to construct wells may not be small because the DOE would have to increase the diameter of the holes and install surface and/or intermediate casing in addition to the completion string. Well development via pumping would also be required to prepare the wells for water level measurement and water sample collection. In addition, obtaining permits from the State of Nevada to pump from such wells has not been successful.

Based on the information currently available, additional hydrologic data from drilling the anomalies in the Crater Flat area would not appear to be relevant to assessing radionuclide migration from the Yucca Mountain repository to the compliance boundary. The DOE does not intend to complete any of these holes as monitoring wells, but will record the approximate depth to water if the water table is encountered. We will continue to share our plans with the Board as those plans are developed.

**3. Chlorine-36.**

*The Board encourages the DOE to resolve discrepancies in chlorine-36 studies and agrees with the decision to commission a third-party review that includes integrated chlorine-36 and other bomb-pulse data to help address inconsistencies. Such an integrated methodology should include the measurement of tritium. If an accepted integrated methodology could be developed, it could enhance understanding of hydrogeologic controls on fast-path flows into the repository and yield a conceptual model consistent with both chlorine-36 and other bomb-pulse data. The Board believes that resolving chlorine-36 discrepancies will require a “root cause” analysis that lays out each step in the procedure, how the discrepancies were addressed by each of the two analytical groups, and what each set of measurements has in common as well as what differences exist and the potential reasons for these differences and actions for resolving them.*

**Response:**

The DOE appreciates the Board’s support of our third party approach, utilizing researchers from the University and Community College System of Nevada (UCCSN), to continue the Cl-36 work and the general approach of using a suite of bomb-pulse isotopes (Cl-36, I-129/127, and Tc-99).

The DOE notes the Board’s recommendation that tritium measurements be included as part of the integrated approach. Additional tritium measurements are not part of the UCCSN Cl-36 study; however, the U.S. Geological Survey – Los Alamos National Laboratory (USGS-LANL) Cl-36 validation team and the UCCSN team will evaluate the tritium data in concert with the other isotopic data with the goal of developing a conceptual model consistent with all of the data. The DOE also notes the Board’s recommendation that resolving the discrepancies will require

a “root cause” analysis. The summary report being developed by the USGS-LANL CI-36 validation team will contain a discussion that lays out potential “root causes” for the CI-36 discrepancies. In addition, the methodology and approach outlined by the UCCSN researchers has a reasonable chance of satisfactorily resolving the discrepancies and getting at the root cause. Interested members of the Board and staff are invited to the quarterly meetings on CI-36 at University of Nevada in Las Vegas to participate in the discussions and offer their opinions and insights. The DOE will keep the Board informed of the schedule for quarterly meetings and of significant developments resulting from the CI-36 study.

## **Issues Relating to Potential Waste Package Corrosion**

### ***1. Microbial activity.***

*Decreasing nitrate concentrations with depth, as shown in one of Bo Bodvarsson’s slides, suggest microbial activity. A waste package design that relies on nitrate to reduce the likelihood of localized corrosion must take into account the effects of microbial activity on nitrate concentrations both before and during the thermal pulse.*

### **Response:**

The DOE agrees that a waste package design that relies on nitrate to reduce the likelihood of localized corrosion must take into account the potential effects of microbial activity on nitrate concentrations. Decreasing nitrate concentrations with depth in one borehole, SD-9 (Slide 22, Bodvarsson and Tsang 2003<sup>1</sup>), have alternative explanations, such as complex hydrologic structure, spatial variability within single hydrologic units, pore water chemistry record of temporal changes, or microbial denitrification. For example, the profile of water compositions sampled with depth, such as that from borehole SD-9, is likely influenced by pre-Holocene hydrologic conditions. The concentration of chloride decreases significantly below the non-welded PTn unit, which has been interpreted, using chloride mass balance relationships, to show that more recent infiltration is more concentrated. The deposition and production of nitrate near the ground surface were likely limited during pre-Holocene conditions, similar to the deposition of chloride. The DOE will update the Board on the evaluation of nitrate inventory in the unsaturated zone at future Board meetings.

### ***2. Gas pressure.***

*The maximum temperature at which brines can exist on waste package surfaces is a strong function of gas pressure. Elevated pressures allow brines to exist at higher temperatures, increasing the likelihood that corrosion will be initiated. Even transient elevated pressures could be important. The DOE should provide a careful and complete explanation of gas pressures during the thermal pulse within the drift environment.*

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<sup>1</sup> Bodvarsson, Gudmundur and Tsang, Yvonne 2003. *Flow and Transport in the Unsaturated Zone*. Presentation to the Nuclear Waste Technical Review Board, September 16, 2003.

## **Response:**

Gas pressure within the emplacement drifts is expected to increase only a few tens of pascals during the thermal period, an increase that will have only negligible effect on the temperature range of aqueous solution stability. Although the 2-D coupled process models generally show a pressure increase of one- or two-hundred pascals, this artifact almost disappears when the “near-infinite” equivalent permeability of the drifts is considered within 3-dimensional models. In the more realistic 3-D models, the pressure rise is generally only a few tens of pascals.

This very small pressure increase (tens of pascals) is negligible for all practical purposes. The pressure rise is due to boiling in the rock matrix blocks close to the drifts and the very small limitations on the overall capacity of the system to move the increased mass of gas away from the source (i.e., similar to the pressure increase that forces the generated steam to flow from the rock matrix into adjacent fractures). The gas pressure is also slightly elevated in the fractures, and this slight pressure increase propagates into the emplacement drifts as an imposed condition of the geosphere within the boiling zone. Some of the steam flows from the fractures into the drifts, and this causes a significant reduction in the mass fraction of air in the gas phase within the drifts. The slight pressure increase within the emplacement drifts goes away near the end of the thermal period, after about 1,000 years.

The pressure increases given above are miniscule compared to the ambient pressure at the site and have negligible effect on the boiling point of water. Such temperature adjustments are minor compared to the effect on boiling temperature due to the elevation of the repository. A pressure increase of 10 pascals is one-ten thousandth of a bar. The site elevation is such that it is at an ambient pressure of roughly 0.9 bar. This represents a decrease of one-tenth bar, and it produces a drop of about 4°C in the boiling point of water<sup>2</sup>. Given that the pressure changes we are discussing are about 1/1000 of this elevation related pressure difference, the temperature effect on the boiling point is roughly 0.004°C, which is clearly much smaller than the uncertainty on temperatures in post closure. Similarly, such a slight pressure increase is negligible relative to its ability to raise the boiling temperature of aqueous solutions (or conversely the deliquescence temperature of brines).

## **Issues Relating to Management and Communication**

### ***1. Quality/schedule tradeoffs.***

*The Board appreciates John Arthur’s assurance that the license application schedule is not constraining the quality of work within the Yucca Mountain project. The Board strongly agrees with the DOE that a license application should be filed only when appropriate quality standards have been met. A schedule-driven approach to quality management can potentially compromise*

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<sup>2</sup> BSC (Bechtel SAIC Company) 2002. *Thermal Testing Measurements Report*. ANL-NBS-HS-000041 REV 00. Las Vegas, Nevada: Bechtel SAIC Company.

*the safety culture surrounding the preparation of the license application, thereby making the project vulnerable to poor decision-making. The Board emphasizes the importance and inherent long-term efficiency in “taking the time to do it right.”*

**Response:**

The DOE agrees that a license application should only be filed when the appropriate quality standards have been met. The DOE will not submit a license application to the U.S. Nuclear Regulatory Commission (NRC) until we are satisfied that we have met the necessary quality and regulatory requirements.

**2. Repository performance confirmation.**

*With an operational period that may extend beyond repository closure, it appears that performance confirmation may be a component of the DOE’s proposed radioactive waste disposal system that will span licensing, construction, and possibly operation. Thus, performance confirmation holds the possibility of enhancing confidence in repository prediction not only by “confirming” DOE models but also by testing the underlying conceptual, physical, and mathematical bases of those models. The Board encourages the DOE to have a clear understanding of what it means by performance confirmation and integrate it thoroughly with performance assessment and repository design. This includes the need to establish formal management practices that ensure that appropriate interactions occur between these system components. Moreover, the Board believes that the performance confirmation program can benefit significantly from the input of the interested public and affected parties.*

**Response:**

The Board is correct in noting that the performance confirmation program will continue through initial licensing, repository construction, and repository operation until permanent closure. The program must satisfy NRC licensing requirements in 10 CFR Part 63<sup>3</sup>, including the requirement to continue performance confirmation testing until permanent closure.

The DOE’s license application will provide sufficient information to enable NRC to reach a finding that there is reasonable expectation that waste can be disposed at the repository without unreasonable risk to the health and safety of the public. If the NRC authorizes construction of a repository at Yucca Mountain, the performance confirmation program will continue, focusing on testing the adequacy of assumptions, data, and analyses presented in the license application to support the NRC reasonable expectation finding.

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<sup>3</sup> 10 CFR 63. Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Readily available.

10 CFR Part 63 specifies the types of testing required for performance confirmation, including tests to evaluate:

- Subsurface conditions, including geotechnical and design parameters
- Functions of the natural and engineered barriers
- Waste package condition
- Effectiveness of any design features added after construction authorization, such as borehole seals

Additional testing may be undertaken to enhance confidence in repository performance by testing the underlying conceptual, physical, and mathematical bases of models.

The DOE's formal management procedures will ensure appropriate integration of the performance confirmation program with performance assessment and repository design.

### **3. Program integration and communication.**

*The Board believes that the technical basis documents being developed for the Yucca Mountain Project have significant potential for improving program integration and enhancing program communication with the wider technical community as well as the general public. For gaining the maximum benefit from these documents, integrating their most important conclusions into a concise description of the safety case for a Yucca Mountain repository will be important. However, if the documents are not well integrated or if they contain technical errors, then communication of the safety case to the broad scientific and public audiences will be weakened. Where appropriate, the discussion of relevant analogs can be used as a line of evidence and enhance the DOE's communication.*

#### **Response:**

The DOE appreciates that the Board recognizes the potential of the technical basis documents both in enhancing technical integration, and in informing the wider scientific community as well as the general public. The DOE also agrees that the most important conclusions need to be integrated into a concise description of the performance of the repository system in the postclosure timeframe. Chapter 2 of the Safety Analysis Report in the license application will include a comprehensive discussion of the technical basis for the evaluation of postclosure performance. The technical basis will be supported by relevant analogs when appropriate. The DOE will draw on the technical basis documents along with other technical references in developing this chapter of the Safety Analysis Report. This chapter will include a concise overview of repository safety after permanent closure, including a description of the multiple barriers that contribute to postclosure performance of the repository.

The DOE has scheduled in-depth reviews of the technical conclusions that will be provided in the license application. These reviews will focus on quality and integration of the technical basis for the conclusions on the postclosure performance of the repository system.

The DOE recognizes that a broad-audience document that presents a clear description of the safety case would be desirable. Its function would be to explain to non-specialists why we

believe that there is a basis for confidence in the safety of the proposed system. Such a document is being considered, but its production must await the content of the license application, to assure that the two documents are consistent and to avoid any confusion as to the DOE's position.