

Appendix E

U.S. Nuclear Waste Technical Review Board Correspondence with U.S. Department of Energy

In addition to published reports, the Board periodically writes letters to the Director of the U.S. Department of Energy's (DOE) Office of Civilian Radioactive Waste Management (OCRWM). The letters typically provide the OCRWM with the Board's views on specific technical areas earlier than do Board reports. The letters are posted on the Board's Web site after they have been sent to the OCRWM. For archival purposes, the three Board letters written during the period covered by this report are reproduced here.

The OCRWM typically responds to the Board's reports and letters, indicating its plans to respond to the Board's recommendations. Included here is the OCRWM's response that was received by the Board during calendar year 2005. Inclusion of these responses does not imply the Board's concurrence.

- Letter from B. John Garrick to Theodore Garrish, Deputy Director, OCRWM; April 19, 2005.
Subject: DOE's participation at the February Board meeting
- Letter from Paul M. Golan, Director, OCRWM, to B. John Garrick; December 14, 2005.
Subject: DOE's responses to recommendations in the July 28, 2004 letter
- Letter from B. John Garrick to Paul M. Golan, Director, OCRWM; December 19, 2005.
Subject: DOE's participation at the November Board meeting
- Letter from B. John Garrick to Paul M. Golan, Director, OCRWM; March 6, 2006.
Subject: DOE's participation at the February Board meeting



UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
2300 Clarendon Boulevard, Suite 1300
Arlington, VA 22201

April 19, 2005

Mr. Theodore Garrish
Deputy Director
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Dear Mr. Garrish:

On behalf of the Nuclear Waste Technical Review Board, I thank you and your staff for participating in the Board's meetings on February 9, 2005, in Las Vegas and February 10, 2005, in Caliente, Nevada. The Board's comments on these meetings are summarized below.

Total System Performance Assessment (TSPA). Current TSPA calculations are based on a standard with a regulatory period of 10,000 years. However, the July 9, 2004, decision of the U.S. Court of Appeals for the District of Columbia Circuit, which remanded to the U.S. Environmental Protection Agency its Yucca Mountain repository standard, could result in a longer regulatory period. If the regulatory period is extended, the program could encounter technical challenges, including a need to address in TSPA relevant hydrogeologic and climatic processes that may be significant beyond 10,000 years. The Board requests that the DOE provide descriptions of technical and scientific elements of TSPA that might change if the standard is modified.

Program Integration. Program integration is of continuing Board interest and could potentially affect elements of the DOE's safety case. The Board endorses the DOE's use of a total system model (TSM) for planning and integrating various elements of the waste-management system. We look forward to learning more about TSM model components, structure, output metrics, underlying assumptions, and event uncertainties (e.g., weather events that may cause significant delays).

The design of surface facilities at Yucca Mountain should be an integrated part of the total waste-management system. The Board is concerned that assumptions related to receipt of spent fuel from utilities and the DOE's thermal-management strategy could result in excessive handling of spent-fuel assemblies as fuel is blended and aged before disposal. The Board believes that the DOE needs to evaluate and compare pre- and post-closure human exposure to radiation.

Specifically, the Board recommends that the DOE evaluate the costs and benefits of using dual-purpose (transportation and storage) or multipurpose (transportation, storage, and disposal) casks for transporting, storing, and disposing of spent fuel at Yucca Mountain. The use of such casks has the potential to limit the number of times that spent-fuel assemblies must be handled and, thus, the risks and radiation exposures associated with such handling. The Board also believes that

increasing communication with utilities, the railroad industry, and affected parties could improve planning for developing the waste-management system.

The DOE's focus on a mostly-rail scenario and the planned construction of a branch rail line to Yucca Mountain appear to have constrained planning for truck and intermodal transportation. Delays in the availability of a rail line to Yucca Mountain or the potential that such a line might not be built could result in a significantly larger number of truck shipments than currently anticipated throughout the system or could require intermodal shipments. Provisions for dealing with these scenarios, including cask design, cask availability, rolling stock, use of overweight shipments, and plans for loading and unloading, need to be considered explicitly in transportation planning.

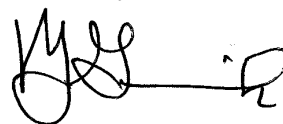
The Board believes that many activities identified in the performance-confirmation program can provide valuable information for validating modeling assumptions that form the basis of the TSPA. For example, hydraulic testing of major block-bounding faults can enhance the technical basis of the analyses supporting the license application. However, the performance-confirmation program appears to be operating independently of TSPA and of the ongoing work on repository design.

The types and structures of organizations that will design, build, and operate a repository at Yucca Mountain and the associated transportation system need to be considered. The qualifications of the participants and the need for interactions among participants, if multiple organizations are involved, could affect both the safety and the efficiency of the overall system. The Board would like to receive a draft of the DOE's implementation plans for construction, management, and operation of the repository and transportation systems.

Science and Modeling Update. The science and modeling update was very worthwhile. For example, the DOE presented state-of-the-art age dating of opal mineral deposits as evidence that seepage rates are unaffected by climate change. Although the large changes in the rate of growth of those minerals may have occurred hundreds of thousands of years ago and are poorly understood at present, ultimately they may provide important clues to the understanding of flow in the unsaturated zone at Yucca Mountain. Other laboratory experiments show that some oxides of neptunium may have low solubilities under a range of environmental conditions. Furthermore, the DOE cited recent reports that neptunium may be incorporated into minerals that can be stable for very long periods. Finally, DOE findings that mixtures of certain salts can raise the temperature limit for deliquescence above 160°C indicate that progress has been made in improving fundamental understanding of the conditions that could produce deliquescence. These examples illustrate the importance of a sustained science program in enhancing confidence in repository performance analyses.

Thank you again for the DOE's support of this meeting.

Sincerely,



B. John Garrick
Chairman



Department of Energy

Washington, DC 20585

QA: N/A

December 14, 2005

B. John Garrick, Ph.D.
 Chairman
 Nuclear Waste Technical Review Board
 2300 Clarendon Boulevard
 Arlington, VA 22201-3367

Dear Dr. Garrick:

Thank you for your April 19, 2005, letter providing the Nuclear Waste Technical Review Board's (Board) response to the information presented by the U.S. Department of Energy (Department) at the Board's meetings on February 9, 2005, in Las Vegas, Nevada, and on February 10, 2005, in Caliente, Nevada. I apologize for the lateness of this response.

In your letter, you asked what changes might be made in the Department's Total System Performance Assessment (TSPA) as a result of modifications to the U.S. Environmental Protection Agency (EPA) standard. As you know, on August 22, 2005, the EPA published a proposed rule to revise the "Public Health and Environmental Radiation Protection Standards for Yucca Mountain." Subsequently, on September 8, 2005, the U.S. Nuclear Regulatory Commission (NRC) published its proposed changes to its regulation, 10 CFR Part 63, "Disposal of High-Level Radioactive Wastes in a Geological Repository at Yucca Mountain, Nevada," to ensure its consistency with the EPA proposal. The Department's path forward for the TSPA will be guided by the outcome of the EPA and NRC rulemakings. Under the proposed changes, the Department's 10,000-year calculation would be extended to time of peak dose within the period of geologic stability (up to one million years) with treatment of seismic, volcanic, and climate scenarios specified.

Features, events, and processes that pertain to the effects of seismic activity on the Yucca Mountain repository natural barrier system to date have been excluded over the 10,000-year period based on low consequence. The justifications for excluding these features, events, and processes for 10,000 years are also applicable to the period beyond 10,000 years because they are not time dependent. Therefore, the Department would not plan to consider the effects of seismic activity beyond those that result in damage to the engineered barrier system. The consequences of seismic activity, properly weighted by probability of occurrence, likely will not have a significant effect on the peak median annual dose. Current analyses indicate that the magnitude and timing of the peak median annual dose depends much more on the degradation of the engineered barriers, primarily the waste package, through general corrosion.

Dike intrusion and volcanic eruption events may occur, and their consequences, properly weighted by probability, should be assessed in an evaluation of repository performance. Current analyses indicate that the mean annual probability of an igneous dike intrusion event is 1.7×10^{-8} per year, which is slightly higher than the 10^{-8} per year regulatory limit. The probability of an

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eruption in the case where a dike intersects the repository is about 0.8. Sensitivity analyses indicate that an igneous intrusion could potentially affect repository performance over a one million-year period. However, these analyses indicate that the weighted consequences of igneous intrusion likely will not have a significant effect on the peak median annual dose. These analyses indicate that the magnitude and timing of the peak annual dose depends much more on the degradation of the engineered barriers, primarily the waste package, through general corrosion. Analyses also indicate that the greatest risk due to a volcanic eruption will occur within the first 10,000 years. The inventory of radionuclides that dominate the risk from a volcanic eruption decay significantly within and beyond the 10,000-year period following repository closure.

Analyses of past climate conditions in the Yucca Mountain area indicate that climatic conditions will change over the period of geologic stability; however, it is not possible to know or predict with certainty precisely when the climate states with peak precipitation will occur. Further, there are too many uncertainties and permutations available in trying to project a future set of climate conditions, and it is difficult to identify specific times when discrete pulses of precipitation should be included in the modeling. The Department expects to use a long-term average climate infiltration rate to address this, as specified in the proposed rules.

With regard to your comments on program integration, the Department is considering different design concepts that will allow receipt of waste as well as concepts that will streamline the handling of waste through the overall process of transportation, aging, and disposal and will keep the Board informed as these concepts mature.

The Department decided last year to proceed with planning for “mostly rail” shipments based on a Final Environmental Impact Study that considered various modes of transportation, including single mode and combined modes. Therefore, we have not undertaken any additional work on an intermodal facility. The Department does recognize, however, that even under the mostly rail scenario, a few reactor plants will be unable to accommodate rail shipments and that there will need to be truck shipments using legal weight and over weight trucks. The Department does not plan to use heavy haul truck shipments to the repository, although heavy haul shipments from reactor sites to a railhead will be considered.

The intent of the Performance Confirmation (PC) Program is to confirm the performance of the barriers and total system as documented in the TSPA for the license application; the PC Program is documented in the PC Plan. The cognizant performance assessment analysts have reviewed the current suite of activities in the PC Program to verify that the Program is focused on processes that are important to performance. Following the completion of the TSPA for the license application and associated supporting documents, additional analyses will be performed to develop parameter selection and/or recommend new PC activities such that the PC Program is contemporary with the information used to support the license application.

The Department will provide the Board with copies of any implementation plans for construction, management, and operation of the repository and transportation systems as they are developed.

The Department continues to benefit from the constructive views of the Board, and we look forward to further dialog on the repository and related issues.

Sincerely,



Paul M. Golan
Principal Deputy Director
Office of Civilian Radioactive
Waste Management



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NUCLEAR WASTE TECHNICAL REVIEW BOARD
2300 Clarendon Boulevard, Suite 1300
Arlington, VA 22201

December 19, 2005

Mr. Paul M. Golan
Acting Director
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Dear Mr. Golan:

On behalf of the Nuclear Waste Technical Review Board, I thank the Department of Energy (DOE) staff and contractors who participated in the Board's fall meeting on November 8-9, 2005, in Las Vegas, Nevada. The Board welcomed the opportunity to review technical and scientific issues currently important to the Yucca Mountain program. Furthermore, the members were pleased with the increased technical content of the presentations, which allowed the Board to explore many important issues more fully. The Board has organized the following comments in the order that the issues were discussed at the meeting.

Program Overview

The DOE has announced significant changes in the Yucca Mountain program that are intended to emphasize safety and reliability and to reduce the complexity of the surface facility design and waste handling operations. The most notable change is the decision to evaluate the development of the transportation, aging, and disposal (TAD) canister system. The Board believes that this system has the potential to address the Board's previously stated concerns related to excessive fuel handling (Board letter to Theodore Garrish, April 19, 2005). However, because nuclear utilities would be responsible for loading spent fuel into the TAD canisters at their power plants, selecting the "right" standard canisters for the TAD will require close cooperation and coordination between the DOE and the utilities. To ensure total system integration, the DOE should determine first-hand the compatibility of possible TAD designs with the capabilities for storage, handling, and transportation available at each reactor site.

The success of the TAD canister system also will depend on integration of the TAD concept into a waste management system that effectively balances preclosure safety and long-term repository performance and that is based on a viable and clearly defined thermal-management strategy. Such a strategy should establish the technical basis for waste acceptance, transportation, waste handling, and emplacement of waste. Thermal criteria should result in waste handling and facility operations that are safe, flexible, reliable, and simple. In addition, key goals of a thermal-management strategy should be to enhance understanding of post-closure near-field and in-drift conditions and to ensure that these conditions do not affect adversely the long-term performance of both the natural- and engineered-barrier systems. Because of the importance of the thermal-management strategy for the entire waste management system, a

group of outside experts should review the strategy periodically during its development, just as experts have reviewed the DOE's Total System Performance Assessment (TSPA).

Science Update

As usual, the Board found the science update particularly helpful; it is apparent that progress has been made since our last meeting. It seemed clear from the presentation that many large-scale, long-term tests are about to be concluded. The Board believes that much can be learned from post-test characterization, including a better understanding of some of the anomalies that have occurred and refinement in the current interpretation of test results. For example, data from the Drift-Scale Test should be used to evaluate near-field thermal-chemical-hydrologic effects. Similarly, other tests conducted behind the bulkheads in the Enhanced Characterization of the Repository Block drift and in infiltration-testing alcoves also have the potential to provide important supplemental information. It is important to complete and fully assess post-test characterization.

The Board continues to support testing in the unsaturated and saturated zones at Yucca Mountain to understand better the contribution of the natural system to repository performance. Understanding of the natural barriers at Yucca Mountain, especially over geologic time, can be increased with studies of natural analogs. For example, the Peña Blanca analog site continues to provide highly relevant data related to radionuclide migration and retention processes at Yucca Mountain. The Board encourages the DOE to continue the studies at the Peña Blanca site.

Thermal conductivity of the rock at Yucca Mountain is of fundamental importance in predicting thermohydrologic conditions in the proposed repository and the tunnel conditions that waste packages will encounter. Uncertainty in thermohydrologic conditions, especially during the thermal pulse, arises in part from the scarcity of *in situ* measurements of thermal conductivity over the range of predicted repository temperatures in the lower lithophysal rocks of the repository horizon. More thermal conductivity data collected in the repository rocks under predicted repository conditions can help reduce thermohydrologic uncertainty and thus improve predictions of long-term repository performance.

Fundamental understanding of the nature of the source term—including spent fuel oxidation, dissolution, and transport—is very important for predicting repository performance. The DOE presented experimental data on spent fuel alteration where Np-U co-precipitation did not occur. Those data suggest that Np transport may not be significantly delayed by co-precipitation. Furthermore, drip-test data show Np concentrations that are not necessarily at Np solubility limits, and thus do not strongly support the assertion that the Np solubility curves used in TSPA are conservative. Continued efforts to achieve greater understanding of the source term are important, and the Board is gratified to see this area emphasized in the portfolio of studies sponsored by the Office of Science & Technology and International.

Conspicuous by its absence was a status report on DOE efforts to determine the source of discrepancies among CI-36 studies. Inconsistencies in past DOE studies of CI-36 in Yucca Mountain create questions about the technical basis of model predictions of water flow and radionuclide transport. The Board looks forward to an update on DOE efforts to address these discrepancies and the possible presence of fast flow paths in the unsaturated zone.

Drip-Shield Design

The DOE provided a comprehensive briefing in response to Board questions about the metals selected for drip-shield fabrication and the potential degradation of the drip shield as a result of corrosion. The Board will evaluate the substantial volume of information on drip-shield configuration, drip-shield emplacement, possible deformation—due to creep—of the drip-shield material under load, and environmental and mechanical degradation. The Board notes that a subsequent presentation by the State of Nevada raised issues about restrictive in-drift operational envelopes and installation tolerances that could potentially increase the difficulty of installing the drip shields remotely.

Because drip shields will not be installed until just before repository closure, which will be many years after waste emplacement, the DOE should evaluate now what factors will affect the final design of the drip shield and explain how, when, and by whom decisions about drip shield emplacement will be made.

Localized Corrosion of the Waste Package

The Board has continuing concerns about the DOE's technical basis for screening out deliquescence-based localized corrosion of the waste package's Alloy 22 outer barrier from Total System Performance Assessment for License Application (TSPA-LA). The Board is especially concerned about the potential for localized corrosion in deliquescent brines formed between 160°C - 220°C from airborne dust that will be deposited on the surface of the waste packages. Although the most recent corrosion data at these temperatures were alluded to, they were not presented or discussed at the meeting. The Board wants to evaluate the significance of the new data and looks forward to receiving them from the DOE as soon as possible.

The Board believes that evidence presented at the meeting supporting the screening out of deliquescence-based localized corrosion from TSPA-LA was not compelling, primarily for two reasons: First, no corrosion data were presented for temperatures above 150°C. Second, data showing stifling of localized corrosion at considerably lower temperatures may or may not be relevant to all conditions under which localized corrosion could occur in the proposed repository. The Board is assessing further the significance of the information presented by the DOE and expects to hold a corrosion workshop to discuss these important issues.

Total System Model (TSM)

The Board believes that the TSM has significant potential as a tool for understanding better the performance of the waste management system. However, it is very important to the success of the model that it incorporates the most up-to-date information (e.g., the availability of spent fuel and on-site waste handling equipment) and that the quality of all input data and assumptions is confirmed. For this reason, the Board recommended earlier in this letter that the DOE determine first-hand the compatibility of possible TAD canister designs with the storage, handling, and transportation capabilities available at the power plants. The Board also

recognizes the potential of the TSM as a valuable tool in preparing the preclosure safety analysis and in addressing important issues related to movement of spent fuel through the waste management system.

The Board would like to understand fully the capabilities and limitations of the TSM in conducting probabilistic assessments, optimizing the waste management system, and analyzing “what if” operational scenarios (e.g., how the waste management system would operate under normal, marginally normal, and off-normal conditions). In addition, the Board would like to know the role that the TSM played in the decision to pursue the TAD canister concept, in particular, the implications of the TAD system for dose, thermal management, and waste handling. We look forward to hearing from the DOE about insights that have been gained as a result of TAD-related studies and analyses.

Conservatism in TSPA-LA

The DOE believes that uncertainties related to TSPA-LA have been addressed using multiple conservatisms and a “cautious but reasonable” approach. However, the DOE does not seem to know the extent to which TSPA-LA is conservative overall. The Board believes that levels of conservatism associated with different components of TSPA-LA vary significantly and that TSPA-LA is, in general, unrealistic. The use of multiple conservatisms (and some non-conservatisms) may mask effects and obscure fundamental understanding of how the engineered and natural barriers would work together as a system to isolate waste. As a result, important constituencies (i.e., the public, the scientific community, and policy-makers) are deprived of meaningful information on which to base their opinions and judgments. The DOE’s contention that conducting sensitivity analyses of TSPA-LA would enhance system understanding has limited validity, in the Board’s view, because the effects of parameter and model changes related to one component of the system or subsystem may be masked by assumptions about other components of the system or subsystem.

The Board believes that in addition to its compliance case, the DOE should develop in parallel a realistic analysis of repository performance based on the assessments by project scientists of how the repository would behave. Such an analysis would be invaluable for fundamental understanding, for informing key constituencies, and for building confidence in the DOE’s estimates of repository performance.

Thank you again for the DOE’s support of this meeting.

Sincerely,

{Signed By}

B. John Garrick
Chairman



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March 6, 2006

Mr. Paul M. Golan □
Acting Director □
Office of Civilian Radioactive Waste Management □
U.S. Department of Energy □
1000 Independence Avenue, SW □
Washington, DC 20585 □

Dear Mr. Golan:

On behalf of the Nuclear Waste Technical Review Board, I thank the Department of Energy (DOE) staff and contractors who participated in the Board's meeting on February 1, 2006, in Las Vegas, Nevada. The Board welcomed the opportunity to review technical and scientific issues important to the Yucca Mountain program.

At the meeting, Russell Dyer presented a new organization chart of the Office of Civilian Radioactive Waste Management showing program activities divided into science, engineering, transportation, operations, licensing, and eight other areas, all reporting to the Office of the Director. Because the Board is charged with ongoing review of all DOE scientific and technical activities in support of the proposed Yucca Mountain repository, not only the science program, the Board looks forward to future interaction with DOE at all program and program management levels. The Board is particularly interested in how a new organization that has all functions reporting directly to the Director will affect the technical direction and quality of the program.

In response to the technical presentations, the Board recommends that the DOE prepare full and realistic process models that account for the transport of neptunium-237 (^{237}Np) and plutonium-242 (^{242}Pu) from the engineered barrier system (EBS) to the biosphere over a million years, the period during which peak dose is predicted to occur. There is considerable evidence that these radionuclides are major contributors to peak dose. At the meeting, the DOE presented its current understanding of the modes of ^{237}Np transport from spent fuel, an understanding that has evolved as a result of a decade of research. The presentation highlighted the limited understanding in this area and showed the importance of continuing current research, especially relating to radionuclide source term exiting the EBS as a function of time. Of continuing and particular interest to the Board are the forms of ^{237}Np and ^{242}Pu exiting the EBS. The presentations by the Nuclear Regulatory Commission (NRC), including the chairman of the NRC Advisory Committee on Nuclear Waste, highlighted the sensitivity of dose results to different models: for example, different assumptions on the partitioning of the dose between inhalation and ingestion. The Board continues to have an interest in a realistic dose assessment to serve as a reference point in discussions of conservatism and whether such differences in modeling as noted are rooted in simplifying assumptions that may or may not be conservative.

The Board is concerned that the methods used by the DOE in its Total System Performance Assessment (TSPA) do not properly represent the natural correlations of some specific parameters. For example, TSPA allows for combinations of physical parameters that produce extreme travel-times (a decade or less and hundreds of thousands of years) that are not considered technically credible. Another example is that peak-dose sensitivity analyses indicate that seepage of water into the drifts is significant to dose but that percolation of the water that produces the seepage is not a significant parameter—a decoupling not well explained. Improved treatment of parameter correlations can enhance the technical credibility of TSPA.

Finally, because the Board is focused on repository performance to peak dose and the DOE continues primarily to emphasize a 10,000-year compliance period, the Board is not getting the information it needs to evaluate the overall performance analysis of the repository. The Board strongly recommends that the DOE adopt a more risk-informed analysis—that is, a more realistic analysis—of the repository over a period that clearly includes the peak dose at the accessible environment.

We look forward to future meetings in which the DOE is prepared to address these issues in a focused manner.

Sincerely,

{Signed By}

B. John Garrick
Chairman