UNITED STATES

NUCLEAR WASTE TECHNICAL REVIEW BOARD

2300 Clarendon Boulevard, Suite 1300

Arlington, VA 22201

May 3, 2004

Dr. Margaret S. Y. Chu
Director
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Dear Dr. Chu:

On behalf of the Nuclear Waste Technical Review Board's Panel on the Natural System, I would like to express our appreciation to you and to the rest of the Yucca Mountain Project team for participating in our March 9-10, 2004, meeting in Las Vegas and for the subsequent Board field trip to Yucca Mountain on March 11. The purpose of the meeting and field trip was to investigate the fundamental scientific and technical basis for estimates of the potential performance of the natural barriers to radionuclide transport under conditions not disturbed by repository heating. The presentations at the meeting were clear, substantive, and helpful. The Board's observations and recommendations from the meeting are presented below.

Increasing Fundamental Understanding

Field and laboratory observations and analyses presented by the Department of Energy (DOE) and others suggest that the natural system provides an effective barrier to migration of some radionuclides over time periods that may be comparable to the regulatory period. However, several key hydrogeologic features or processes that may significantly affect fluid flow and radionuclide transport are presently not well understood, are constrained by limited or poor data, or both.

The DOE often deals with uncertain features and processes by making conservative estimates of their effects on radionuclide transport. Such conservativisms regarding the performance of the natural system tend to emphasize more-rapid advective transport processes. More realistic estimates that might arise from further evaluation of some features and processes could lead to slower transport predictions for some radionuclides. However, there is a possibility that some other poorly understood features or processes may lead to faster radionuclide transport. Therefore, it is important that the DOE develop a better fundamental understanding of the overall behavior of the natural system.

In the following paragraphs, the Board identifies some areas where additional work might increase basic understanding, narrow the wide range of predicted radionuclide transport times, and increase confidence in predictions of the performance of the natural barriers. An enhanced

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technical basis for the performance of the natural barriers is an important part of an overall repository strategy that uses multiple barriers to provide defense-in-depth.

Technical and Scientific Recommendations

Increases in fundamental understanding of the behavior of the natural system could result from scientific investigations conducted in the following three areas. First, although the hydraulic properties of major block-bounding faults, such as the Solitario Canyon fault, never have been field-tested, it seems clear that these faults can influence fluid flow and radionuclide transport substantially. Large-scale hydraulic tests of those major faults are therefore needed. Second, improvements in the characterization of the spatial distribution and sedimentary architecture of the saturated alluvium could substantially enhance fundamental understanding of groundwater flow and radionuclide transport along Fortymile Wash south of Yucca Mountain. For example, the recent sonic log drilled by Nye County is an excellent source of data for supporting studies of sorption of radionuclides in alluvial sediment; additional logs from locations where uncertainties are high have the potential to yield similar benefits. Deeply weathered cobbles from that geologic log suggest the potential for delays in radionuclide transport due to diffusion that could be demonstrated if the DOE conducts field-scale long-term tracer studies (for example, at the Alluvial Testing Complex). These studies should be done. Third, depending on rock properties such as fracture frequency and thin coatings on the fracture faces, matrix diffusion could either increase or decrease current estimates of radionuclide transport time by thousands of years. For this reason, a better empirical basis for predicting matrix diffusion is needed.

Three other areas — colloid-facilitated transport, the active fracture modeling approach, and boundary fluxes on the site-scale saturated zone model — are significant elements of DOE analyses that have substantial unresolved uncertainty. First, evidence from a nuclear weapons test site suggests that some water-borne colloids can lead to rapid radionuclide transport in the saturated zone. Laboratory and computer studies conducted by the DOE show that other colloids might substantially slow radionuclide migration. Consequently, understanding of this phenomenon should be improved by field, laboratory, and modeling studies. Second, for unsaturated zone fluid flow and radionuclide transport, predictions are influenced significantly by assumptions inherent in the formulation of the active fracture model (AFM). The AFM needs to be tested and evaluated to establish a technical basis for using this approach. Third, in the saturated zone, the technical basis for the DOE's site-scale flow model would be stronger if the model were more consistent with the most recent regional model calculations of flow across the site-scale model boundaries. Updating the DOE's model on the basis of these calculations could affect predictions of radionuclide transport times.

Multiple Lines of Evidence

The Board continues to believe that an integrated explanation is needed of how elements of the repository act as a system to isolate waste. Such an explanation should rest on a fundamental understanding of the system as discussed in previous paragraphs and on multiple lines of evidence. Multiple lines of evidence and argument can be used to supplement and evaluate the conceptual understanding of the natural systems at the site, the models used to represent those concepts, and the scenarios predicted by those models. The Peña Blanca analogue site in Chihuahua, Mexico, having many similarities to Yucca Mountain, provides a good opportunity to evaluate, for example, whether consideration of secondary mineralization processes may reduce overall system dose estimates substantially and what effect alpha decay of radionuclides in minerals may have on mobility. The Board commends the Science and Technology program for its plans to test Yucca Mountain modeling approaches at the Peña Blanca analogue site. Naturally occurring radioisotopes at Yucca Mountain provide another valuable line of evidence for flow and transport. Additional isotopic data, such as carbon-14 measurements, collected from discrete zones in the flow path from Yucca Mountain, could be used to test and evaluate DOE models and predictions and to constrain recharge rates in the model domain. In summary, the validity of model forecasts can be evaluated better in the presence of a list of independent physical and chemical lines of evidence that support or challenge the forecasts.

Concluding Comments

At a May 2002 meeting of the Board, you stated your intention to devote attention to aspects of the natural system, and we are encouraged by your interest in this important work. Observations during our field trip to Yucca Mountain demonstrated two things in particular: (1) better understanding the behavior of the natural barriers at Yucca Mountain is challenging because of the complexity of the geologic system, and (2) based on recent progress in characterizing the natural system, enhanced understanding of the natural system is attainable. The Board believes strongly that the important work you have done in this area should be continued.

Again, we thank you, your staff, and your scientists very much for an excellent meeting and field trip.

Sincerely,

Richard R. Parizek

Richard R. Parizek
Chair, Panel on the Natural System