Department of Energy
Washington, DC 20585

JAN 31 2003

January 24, 2003

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

Dear Dr. Corradini:

Thank you for your letter of November 22, 2002 expressing the Board's perspective on information presented by the Department at the Board's September 2002 meeting and on information from my letter to you of September 6, 2002.

DOE appreciates the Board's continuing review of our activities as we develop a license application for a repository at Yucca Mountain. Our responses to the views expressed by the Board are discussed in the attachment to this letter.

The Department has benefited from the constructive views of the Board. As the Department proceeds to develop a license application, we look forward to continuing our dialogue with the Board.

Sincerely,

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

Enclosure

Responses to the September 22, 2002 letter to DOE from the Nuclear Waste Technical Review Board

Natural System

The Board believes that the interim report of the DOE-supported Yucca Mountain Igneous Consequences Peer Review Panel is a significant accomplishment and that the panel has made progress in defining the fundamental processes. This work is very important because on the basis of the most recent performance assessment, volcanism appears to be the largest potential contributor to dose. For this reason, the Board waits with interest for the panel's final report.

Response: The DOE agrees with the Board's assessment of the interim report from the ongoing Igneous Consequences Peer Review Panel[1]. We are looking forward to the Panel's final report. The interim report summarizes the Panel's key issues, including dike and crack propagation, particularly in the vicinity of the repository, and the complex processes that occur once magma interacts with the repository drifts. Within these areas, we believe that four issues are of particular importance, and discuss briefly below how the Project is addressing these issues.

1. Dike tip phenomena during dike ascent and dike/drift interaction

   The dike tip cavity region may have an important impact on dike propagation and the nature of the initial magma/drift interaction. There are complex interacting processes that control the cavity size. Because we have little information to predict the details of the cavity region in a propagating dike, our approach is to parameterize this zone with respect to length and pressure and perform parametric studies to assess the effects under a wide range of conditions. In the dike propagation code, the cavity pressure will be specified and the appropriate cavity length that is required to accommodate this pressure will be calculated.

2. Magma viscosity as a function of temperature, volatile content, and bubble content, and its impact on magma migration down drifts and magma/waste package interactions

   The effects of temperature, dissolved volatile content, and exsolved vapor bubbles on the shear viscosity of basaltic melt should be included in future studies of the material properties of potential disruptive Yucca Mountain basalt. We plan to do calculations with higher and/or lower viscosities. The numerical model in the baseline version of the Computational Fluid Dynamics Library will only allow a fixed Newtonian viscosity. However, we plan to incorporate variability in viscosity related to

[1] Budnitz, R.J., Detournay, E.M., Mastin, L., Pearson, J.R.A., Rubin, A.M., and F.J. Spera 2001. *Yucca Mountain Igneous Consequences Peer Review Panel Interim Report.* Las Vegas, Nevada: Igneous Consequences Peer Review Panel. ACC: MOL.20011010.0084.

temperature and volatile-content this year. Incorporation of the effects of bubbles with a capillary number approach will be considered in plans for later years, and could yield useful confirmatory information.

3. The dog-leg scenario (magma intrudes drifts and initiates a second dike at some distance from the original dike)

   Magma/drift interaction modeling will include 3-D models to simulate magma flow from a dike into a drift, as well as the continuation of magma flow upward within the original dike and within a possible second dike. Two cases will be modeled to assess the plausibility of including the dog-leg scenario in the Total System Performance Assessment (TSPA). The first case will assume a short secondary dike has formed at the end of a drift in order to determine initial magma injection flow rates or pressure within the second dike for input into dike propagation models. The second case will assume a second dike has formed at the end of a drift in order to determine the difference in magma flow rates within the primary and secondary dikes due to viscous drag within the intervening drift and differences in the hydraulic properties of the two dikes.

4. A shock wave propagates down a drift following explosive magma decompression

   The Panel concluded that rising magma would be partially degassed before it intersects a drift, minimizing to some extent the magnitude of a potential shock wave traveling down a drift. Scoping calculations that take into account the geometry of initial dike/drift intersection and the presence of waste packages within the drift also indicate that shock wave formation will be diminished given more realistic models of dike/drift interactions. Modeling planned for this year will provide a more detailed and realistic technical basis to assess shock wave phenomena within drifts.

The Board also is pleased that one of the priorities you have given the new Science and Technology unit is to determine whether the potential repository's natural system makes a greater contribution to isolating and containing waste than current performance assessments suggest. If a strong technical case can be made for such an increased contribution, it would provide additional defense-in-depth, thereby increasing confidence that public health, safety, and the environment would be protected over the long term. For this reason, the Board believes that work in this area could have a major payoff and suggests that it be accelerated.

Response: The DOE agrees with the Board's recommendation that the new Science and Technology (S&T) Program should have as one of its priorities to work on improving our understanding of natural-system performance. We are currently evaluating a whole range of ideas for the first round of projects to be supported under the S&T Program, and ideas related to studying the natural system are certainly among those high on our list, along with ideas involving new or improved technologies that can achieve efficiencies and savings. However, it is important to note that benefits in all of these areas may take years to realize.

The S&T program objectives continue to be a) to improve existing and develop new technologies to achieve efficiencies and savings in the waste management system; and, b) to increase understanding of repository performance. Major additional benefits will include promoting technical excellence, maintaining leadership in nuclear waste management, and assuring cognizance of emerging technical developments. Our current efforts include developing long-term strategic research plans for all of the technical areas within OCRWM's purview (with the assistance of external subject-matter experts). A subset of these technical areas will be selected for initiation in Fiscal Year 2003. The balance will help us as we develop the long-term program (Fiscal Year 2004 and later).

Any technical insights, technical data, or new technical tools derived from the S&T work will be folded into the LA process wherever appropriate.

For nearly two years, the DOE has been trying to explain two conditions that have been observed at Yucca Mountain. The first involves two independent laboratory analyses that result in contradictory data with respect to the presence of bomb-pulse chlorine-36 at the repository horizon. The second condition involves moisture observed within the closed-off part of the cross-drift and whether this moisture is due to condensation or infiltration. To date, the DOE has not provided a persuasive explanation for either of these two conditions.

The Board strongly urges the DOE to continue its efforts in these two areas and looks forward to reviewing the work in the near future. The Board believes that it is essential that the DOE develop an understanding of key processes affecting repository performance, specifically seepage and the potential for waste package corrosion when packages are subjected to a range of conditions representative of the postclosure in-drift environment.

Response: The DOE agrees, and is continuing investigations focused on these two issues (^{36}Cl and moisture in the cross-drift). The linkage to potential waste-package corrosion is discussed later in this letter.

With respect to the chlorine-36 issue, the DOE is pursuing a resolution of the legacy discrepant data sets by (1) having the institutions involved to date document the results to date and propose a path forward for resolution of the discrepancies, and (2) conducting an independent new validation study as a parallel, complementary effort. Individuals from domestic or foreign academic/technical organization(s) with the requisite expertise will be selected to conduct this new study. One of the key criteria for selection of the individual(s) will be no prior involvement in the ^{36}Cl/Cl work at Yucca Mountain. The independent validation study will include a new sampling and analysis program to attempt to better understand the previous ^{36}Cl/Cl observations. The background, about which we believe the Board is fully aware, is that because of differences in the implications for unsaturated-zone flow between important ^{36}Cl data and other data, the DOE initiated a validation project in 1999 to address the presence of bomb-pulse ^{36}Cl at

the repository horizon. All of the analytical data generated during this ^{36}Cl ongoing validation project are being compiled and a summary report, due June 11, 2003, is being prepared jointly by the United States Geological Survey (USGS), Los Alamos National Laboratory (LANL), and Lawrence Livermore National Laboratory (LLNL). The report will contain a recommendation for a path forward based upon a review and interpretation of the existing data.

The report will include the latest analyses conducted in the spring of 2002 that focused on core from Niche 1 in the Exploratory Studies Facility where previous LANL results indicated a high probability of finding bomb-pulse ^{36}Cl. Selected intervals of remaining core samples were split and allocated to the USGS and LANL for processing. Isotopic analyses of rock leachates were conducted by LLNL. USGS leachates yielded $^{36}Cl/Cl$ ratios of 244 E-15 to 708 E-15 with Cl concentrations ranging from 0.17 to 0.26 mg/kg. LANL leachates yielded larger values of 1140 E-15 to 8580 E-15 with Cl concentrations of 0.13 to 0.67 mg/L. Because the water-to-rock ratios are 1:1, the measurements of Cl concentrations are comparable. To further investigate the source of the differences, the USGS crushed and leached 99.999 percent pure computer-chip grade silicon and determined that the crushing blanks used in the analysis were acceptable. . LANL investigators have not yet performed a similar test. The reasons for the disagreement in the USGS and LANL results are not currently understood, which is why we have decided to pursue the new independent validation study.

DOE looks forward to providing further details and results of the independent validation study at future Board meetings.

With respect to the second issue, moisture was found in several segments of the closed-off section of the cross drift during entries between September 1999 and June 2002 to collect samples, install additional bulkheads, and conduct other construction and repair activities. The moisture was observed at different locations at different times. There is indication that the amount of moisture decreases with time, especially in 2002 after the power to the tunnel boring machine was cut off. This trend will be further confirmed in the next entry. All available data, including geochemical measurements of water collected, indicate that the moisture observed in the closed off sections of the cross drift is likely to be condensate. The water samples collected in the June 2000 entry had low chloride and silicate contents (Cl was 0.23-1.44 mg/L as compared to cross drift pore water data of 19-66 mg/L. SiO_2 was 0.24-0.42 mg/L as compared to cross drift pore water data of 40-65 mg/L). The moisture is likely driven by temperature gradients, possibly associated with residual heat from cross drift excavation, power consumed by the tunnel boring machine parked at the terminal end of the cross drift, and other electrical instrumentation underground. Other indicators of condensation include the observation in October 2001 of droplets on a painted surface where the paint effectively isolated the exposed surface from the underlying rock. Droplets and rust were observed on other metal surfaces of underground structures during the entries. Observations and

early data are documented in the report *In Situ Field Testing of Processes.*[2] This report will be revised in 2003 to include additional data collected in the cross drift.

Only limited samples have been collected in the cross drift so far. In response to the need to distinguish clearly whether the moisture observed is due to condensation or seepage, DOE increased the number of instruments emplaced in the closed-off sections of the cross drift in October and November 2001 and installed a fourth bulkhead. The first two bulkheads were installed in June 1999 and the third bulkhead in July 2000 to isolate the tunnel boring machine. The first bulkhead has been open since July 2002 to accommodate activities related to rock properties testing. The last three sections of the cross drift are expected to be closed off for at least another year so that we can continue the investigation of moisture observed in the cross drift. The currently available instruments in the closed-off sections include hanging tarps, pH strips, relative humidity, temperature, and pressure sensors, electrical resistance probes along the drift floor, psychrometers installed in boreholes, and dedicated water collectors at a location that was previously observed to be wet. The transducers at the bottom of water collectors have detected no signal so far, indicating no collection of water at this location. The collectors are designed either to collect pure condensate or to collect condensate and seepage. We will use the information from the collectors and all other instruments to help resolve the source of moisture observed within the closed-off part of the cross drift and to evaluate whether this moisture is due to condensate or seepage.

In addition to field monitoring activities, DOE has started a modeling study aimed at developing a better understanding of the moisture and gas flow within the closed-off sections, taking into account the evaporation and condensation processes and moisture movement in the surrounding fractured rocks. The surrounding rocks provide water and vapor for condensation and flow paths for seepage into the drift.

Engineered System, Including Repository Design

The Board has reviewed your letter of September 6, 2002, and the DOE presentations on repository design at the Board's May and September meetings. Still unclear to the Board are what decisions the DOE has made about repository design. However, in your September 6, letter and the DOE presentations, the DOE appears to have decided to seek a license for constructing a repository based on a design "... that results in thermal conditions at the higher end of the expected range, provides a better balance of postclosure thermal conditions and preclosure advantages for construction and operations, flexibility and cost." We request that the DOE provide the Board with the criteria, analyses, and weighting factors that constitute the technical basis for the apparent selection of the repository design as stated in your September 6, letter.

Response: As a general matter, OCRWM has not developed or used quantitative "weighting factors" in an explicit sense in any of its decisions about the thermal-

[2] BSC (Bechtel SAIC Company) 2001. *In Situ Field Testing of Processes.* ANL-NBS-HS-000005 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20020108.0351

operating-mode issue. The issue is much too complex, involving as it does judgmental tradeoffs among factors that we have not expressed in a common framework for explicit "weighting."

The criteria that the Department used as the basis for selecting the design to be used as the basis for the LA were documented in the report *License Application Design Selection (LADS).*[3] The LADS study describes these criteria as being applied qualitatively rather than quantitatively. Of the criteria, the most important was the objective criterion of long term performance. That criterion did not dominate the decision, because all of the designs examined in the LADS study were found to meet the postclosure performance criterion by a large margin, regardless of whether they employed hotter or cooler operating modes. The postclosure criterion used in the LADS study is consistent with the standard promulgated by the EPA in 2001.

The selection of the preferred design of the LADS study instead involved balancing a potential reduction in uncertainty in long term performance, for which there is a large safety margin, that could be obtained by lower-temperature operation, against a certain increase in worker health effects, operational impacts, and cost resulting from the measures needed to achieve a lower-temperature mode. This balancing was inherently judgmental, and supported a decision to select a hotter operating mode as the basis for LA. There have been subsequent refinements of the design concept selected in the LADS study. However, the Department's considerations still involve the same balancing between potential reductions in uncertainty in postclosure performance projections that are well below regulatory limits, and certain increases in impacts in the preclosure period.

Of course, the Department recognizes that a crucial element of NRC's regulatory decision will be whether the analyses and data submitted by the applicant (DOE) are adequate to support a positive decision, and that uncertainties in the analyses are a central part of why the regulatory decision will not be easy. However, even if the uncertainties in analyzing a colder operating mode are smaller than those for a hotter operating mode, which may or may not turn out to be the case in the end, it is DOE's current judgment that either operating mode will meet the NRC standards for post-closure performance with a large margin, and that uncertainties arising elsewhere in the overall analysis dominate.

Undersecretary Card stated at the NWTRB meeting in May 2002 that the Department is committed to maintaining a colder-operating-mode option until it is either selected or no longer important. The Department has done conceptual design work and layouts for such an option, but based on the above its License Application will be based on a hotter operating mode.

According to the DOE presentation made at the September Board meeting, the DOE's design decision seems to be supported by the following two conclusions: (1) projected performance for the high-temperature design is comparable to a low-temperature design

[3] CRWMS M&O 1999. *License Application Design Selection Report.* B00000000-01717-4600-00123 REV 01 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990908.0319.

and, in any case, is well below the regulatory limit; and (2) overall uncertainty in the projected performance of the two designs is roughly equivalent. In response to the DOE's decision, the Board has several comments on the technical basis for these assertions.

The DOE's presentation on corrosion testing may call into question the first conclusion. The increase in corrosion potential due to the presence of nitrate leads to less of a margin at temperatures above 140°C. Moreover, in back-up material from the presentation, the short-term weight-loss measurements based on linear polarization, when extrapolated to higher temperatures, show a significant increase in the rate of corrosion and indicate a definite thermal dependency that is not reflected in current models of performance assessment. The Board encourages continued corrosion testing and analysis supporting basic understanding of waste package corrosion and the in-drift environment.

Regarding the second conclusion, the DOE asserted at the meeting that performance assessment shows that the ranges of dose uncertainty for high- and low-temperature repository designs are similar. The Board notes that performance assessment is not capable of showing uncertainty unless the models appropriately incorporate uncertainty. Some parts of some key performance assessment models for the evolution of waste package environments and for corrosion at high temperatures are not based on data but on a number of assumptions. For example, TSPA assumes that there will be no liquid water above 120°C and no significant separation of chloride ions from beneficial anions and that low-temperature corrosion models are valid at high temperatures. To use these assumptions about high-temperature uncertainties as input into TSPA models and then say that performance assessment reveals that uncertainties are equivalent for high- and low-temperature operations constitute, in the Board's view, circular and therefore faulty reasoning.

The Board has noted for quite some time that the DOE's estimates of the total uncertainty in projected repository performance presume that the underlying conceptual models used to analyze both the low-temperature design and the high-temperature design are appropriate. For example, the models should capture relevant thermal sensitivities in a technically defensible manner. Many experiments, such as the drift-scale thermal test and additional high-temperature material investigations, have not been completed. Thus, the DOE's second conclusion may be premature.

Response: DOE agrees with the Board comment on the need for continued corrosion testing and analysis to improve basic understanding of waste package corrosion and of the in-drift environment. DOE has been developing new data to support development of and validation of our corrosion models. The new testing and results presented to the Board at the September 10, 2002 meeting are part of the Project's ongoing work to enhance basic understanding of the corrosion processes and improvement of the models. An increase in the corrosion potential with nitrate-containing solutions above 120°C

(Gordon[4], Slide 13) is observed. Nitrate solutions are known to be oxidizing under acidic conditions. The oxidation-reduction characteristics of the nitrate-nitrite-ammonium-nitrogen system are complex and the Project is analyzing this system in terms of the expected repository conditions. In addition, the Project believes that the possibility of development of such corrosion environments to a significant extent on the surface of the waste package is highly unlikely due to the presence of the drip shield.

With the drip shield intact, the potential waste package surface environment is expected to be a thin aerated brine film formed by deliquescence of soluble salts in the dust deposits. Chemical analysis of typical dust deposits suggests that the brines likely to form from the deliquescence of these deposits will not evolve to calcium and/or magnesium chloride type brines. Thus, the maximum expected boiling point of these aqueous films are approximately 125°C to 135°C, characteristic of a concentrated sodium/potassium chloride/nitrate environment. Such an environment is similar to the Simulated Saturated Water environment that has been used for testing at 120°C. Cyclic polarization tests indicate that there is greater than a 450 to 700 mV margin between the corrosion potential and any apparent passive film breakdown potential at temperatures up to 120°C (Figure 3-444, page 3-58, of the *Waste Package Degradation Process Model* report[5]). Thus, the assumptions related to applicable environments for extrapolation of corrosion rates appear to be supported by the new data.

The temperature dependency cited by the Board is being evaluated within the on-going testing program. The short-term electrochemical tests (linear polarization tests shown in Gordon[6], Slide 25) are intended to provide only the temperature dependency i.e., the slope, and not absolute corrosion rates. The rates for uniform general corrosion will continue to be obtained from the Long-Term Corrosion Test Facility. The project also believes that the temperature dependency observed from the tests should be regarded as a weak dependency, with the activation energies in the range of 17 to 23 kJ/mole. Extrapolation of the corrosion rates to 140°C and 160°C using these activation energies would result in a corrosion rate increase of approximately 2 to 2.5 times. This increase would have insignificant effect on the waste package performance in view of the extremely low corrosion rates measured in the Long-Term Corrosion Test Facility (0.01 microns/year after a two-year exposure).

The temperature dependency of the corrosion rates was included in the analyses documented in Section 7.3.5 of the *FY 01 Supplemental Science and Performance Analyses* (SSPA) report[7]. These analyses were conducted with significantly higher

---

[4] Gordon, G. 2002. *Update on Corrosion Testing.* Presentation at the Nuclear Waste Technical Review Board Fall Meeting, September 10, 2002. Las Vegas, Nevada.

[5] CRWMS M&O 2000. *Waste Package Degradation Process Model Report.* TDR-WIS-MD-000002 REV 00 ICN 02. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001228.0229.

[6] Gordon, G. 2002 *(op. cit.)* .

[7] BSC (Bechtel SAIC Company) 2001. *FY 01 Supplemental Science and Performance Analyses, Volume 1: Scientific Bases and Analyses.* TDR-MGR-MD-000007 REV 00 ICN 01. Las Vegas, Nevada: Bechtel

general corrosion rates at higher temperatures to account for the uncertainties in the Long-Term Corrosion Test Facility corrosion measurements and the possibility of the occurrence of magnesium/calcium-chloride environments. General corrosion rates for Alloy 22 at 25, 60, 125, and 165°C were calculated using a temperature dependent corrosion model with activation energy of about 36 kJ/mole for the temperature dependency. The temperature of 165°C was selected to represent the highest temperature for an aqueous condition that may result from deliquescence of highly hygroscopic salts such as $CaCl_2$ and $MgCl_2$ that could be deposited on the waste package surface from dripping water. The median of our distribution for the general corrosion rate at 165°C is about 1.0 micron/year and the upper bound is about 3.0 microns/year. Although it is not expected that aqueous conditions can be sustained on the waste package at 165°C, even with the use of these high corrosion rates the waste package failure times are significantly beyond the regulatory period of 10,000 years. The variation in the general corrosion rate is considered to be solely due to uncertainty.

It should also be pointed out that the Project removed the temperature dependent corrosion model from the *Final Environmental Impact Statement* (FEIS)[8] because the model showed the waste package failure times are significantly longer than those calculated without the temperature dependant model. This is due to the fact that the waste packages remain at high temperatures for a relatively shorter period of time compared to the low temperature regime. The decision to remove this model was made to provide more conservative dose estimates.

In summary, DOE is continuing to develop data contributing to a better understanding of corrosion processes and will incorporate these data into the models supporting the TSPA for the LA.

The DOE agrees with the Board that "performance assessment is not capable of showing uncertainty unless the models appropriately incorporate uncertainty." To that end, the Project has been working on several fronts to develop models that represent advances compared to those used in the TSPA-SR. Some of the Board comments above seem to be based on assumptions in the TSPA-SR that have now been supplemented by data to provide the firmer foundation that the Board apparently feels was lacking earlier. This is particularly true for Board concerns about the TSPA approach regarding waste package environment and corrosion. For the high-temperature and low-temperature operating modes considered by the Project, the TSPA models associated with the waste package environment and corrosion are equally applicable based on the available data. Regardless

---

SAIC Company. ACC: MOL.20010801.0404; MOL.20010712.0062; MOL.20010815.0001; BSC (Bechtel SAIC Company) 2001; *FY01 Supplemental Science and Performance Analyses, Volume 2: Performance Analyses.* TDR-MGR-PA-000001 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010724.0110.

[8] DOE (U.S. Department of Energy) 2002. *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada.* DOE/EIS-0250. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20020524.0314; through; MOL.20020524.0320.

of the thermal strategy adopted, the temperature at which the liquid contacts the waste package for the initiation of corrosion is dependent on the deliquescence of the soluble species in the waste package surface deposits.

In order to characterize high-temperature corrosion processes, the Project is conducting tests in highly corrosive environments such as concentrated bulk calcium chloride environments (8 to 9M) with and without nitrate at temperatures above 120°C. The preliminary results from these tests were presented to the Board in September 2002. These results showed that there is little margin between Alloy 22 corrosion potential and the critical potential for the initiation of localized corrosion. However, the presentation also included results of aqueous film corrosion tests (Gordon[9], Slides 14-15) with temperatures as high as 150°C and 22.5% relative humidity using polished Alloy 22 specimens. The calcium chloride concentrations were very high (up to ~62% calcium chloride) under these test conditions. Results to date indicate no evidence of localized corrosion attack under these aqueous film conditions.

The temperature dependency for the extrapolation of low-temperature general corrosion rate data to higher temperatures was discussed above in response to the Board's comment on thermal dependency, and was shown to have an insignificant effect on waste package performance.

The Board observes that future results of ongoing experiments such as the drift-scale thermal test could provide additional information relevant to modeling of thermal processes, and that some of DOE's conclusions may therefore be premature. We agree. However, we believe that the information available and used to date is sound enough to support all decisions made to date.

Integrated Repository System

The Board understands that the DOE realizes that the repository safety case not only must rely on complex calculations of performance assessment but also must include multiple lines of evidence and argument, which could include natural and man-made analogues and traditional notions of defense-in-depth. The Board also supports the DOE's recognition that the safety case needs to address various audiences, including those not directly involved in the licensing process. International organizations, such as the Nuclear Energy Agency of the Organization for Economic Cooperation and Development, have assembled reports on this subject. The Board recommends that the DOE give serious consideration to the logic developed in those reports as well as the specific suggestions they contain.

Response: The DOE appreciates the Board's observations that the safety case will need to address audiences beyond those involved directly in the NRC licensing process. The

---

[9] Gordon G. 2002. *(op. cit.)*

licensing process itself will address multiple lines of evidence such as those suggested by the Board, for example through the requirements for descriptions of capability of the natural and engineered barriers included in the system, and through DOE's use of analogue information as an additional line of evidence to support several of the analyses.

The DOE also recognizes the need for effectively presenting the safety case to broader audiences. The DOE will continue to evaluate recommendations from the Nuclear Energy Agency and others in the international community both for improving the way the Program's safety-case logic is presented, and for improving the safety-case presentation itself.

Presentations at the meeting and the short roundtable discussion at the end of the meeting highlighted several points. The DOE's projections of repository performance, derived from performance assessment, have varied considerably over the last two years and differ in many important respects from those carried out by the Electric Power Research Institute and other groups. Many of these differences can be traced to the assumptions used and the influence of new data. However, confidence in these projections will depend in part on understanding and explaining clearly why variations arise. The Board therefore urges the DOE to analyze the different estimates, assess their significance, and address any concerns that may arise about the overall uncertainty in estimating repository performance. The stability of these projections is an important element in building confidence.

Response: The DOE recognizes the value of such comparative analyses as the Board is recommending. To this end, the Project included discussions of model changes since TSPA for Site Recommendation and their impacts at the subsystem and system level in the SSPA (Volume 2, sections 3 and 4). Summaries of the SSPA model changes and their impacts were presented to the Board in June of 2001. Briefer discussions of model changes were included in the documentation of the TSPA update to support the FEIS.

Recent EPRI results were not available at the time of the SSPA and FEIS, and differences between the EPRI and the DOE analyses were therefore discussed only in very general terms (e.g., presence or absence of a model for diffusive transport, differing assumptions about water consumption by the receptor) at the Board meeting in September 2002. Because both the DOE and EPRI models are continually evolving, the DOE expects to do a detailed comparison between the two only after the completion of the TSPA-LA. In the interim, the Program will attempt to understand the reasons for any important differences, so that this understanding can inform the ongoing TSPA work.

The Board is pleased that the DOE has carried out the "one-on" barrier analysis. The roundtable discussion on this topic at the meeting suggested both the value and the potential limitations of such analyses. On balance, however, the Board believes that such analyses utilizing different approaches can provide important insights into the roles of the different natural and engineered barriers. For that reason, the Board urges the DOE

to continue supporting this kind of work and to consider using it to better articulate its repository safety case.

Response: The DOE recognizes both the value of the "one-on" style of analyses in providing insights into barrier performance and the potential limitations noted during the roundtable discussion at the September 2002 Board meeting. As discussed in Section 7.2.3.1 of the *TSPA-LA Methods and Approach* document[10], the DOE may use sequential one-on analyses as one of several types of analyses included in the confidence-building activities that will support validation of the TSPA-LA model. Other types of possible analyses include comparisons to simplified models, detailed analysis of selected deterministic cases, and neutralization or "one-off" cases. For the descriptions of 10,000-year barrier capability required by 10 CFR Part 63.115[11], the DOE proposes to supplement these analyses with additional techniques including intermediate performance measures from the full TSPA and pinch point analyses that report radionuclide mass flux or concentrations at selected interfaces between model components (Section 8.3 of the *TSPA-LA Methods and Approach* document).

The Board still has questions about the relative role and scope of the DOE's proposed research and development, science and technology, and core science programs. As indicated in the DOE's letter, the scope of performance confirmation (PC) is limited to a regulatory context. The Board believes that a PC program should focus on confirming the safety case by challenging the validity of estimates of long-term repository performance and their underlying assumptions. The Board would like to understand the key elements of the DOE's PC plan; the specific tests and related analyses considered a priority for the PC plan for license application; the testing that will be undertaken during repository construction; and how PC information will be integrated and used by the project.

Response: The DOE believes that the Performance Confirmation program will represent only a subset of a much more comprehensive test and evaluation program.

Based on the language in 10 CFR Part 63[12], the DOE is revising its PC program to focus resources using a risk-informed, performance-based (RIPB) approach. A formal decision analysis process is being used to evaluate the value (in terms of confirming expected barrier performance) and cost of several hundred combinations of a PC parameter and a data-acquisition method. The results are being assembled into several alternative portfolios. One portfolio will be selected soon for development to support the LA. The

[10] BSC (Bechtel SAIC Company) 2002. *Total System Performance Assessment-License Application Methods and Approach.* TDR WIS-PA-000006, Rev. 00, Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.200202923.0175.

[11] 66 FR 55732. Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, NV. Final Rule 10 CFR Part 63. US Nuclear Regulatory Commission.

[12] *Ibid.*

alternative portfolios under development include activities to confirm barrier performance (using the RIPB approach), as well as activities to meet NRC requirements in 10CFR63 Subpart F that must be addressed independent of their significance to barrier performance or total-system performance.

In addition to the baseline work, the Science and Technology Program may develop data, test techniques, or design enhancements that could be brought into the testing programs after initial submittal of a license application or at an appropriate time during the construction and operation of a repository at a later stage.

The proposed PC program is expected to be mature enough to present to the NWTRB at its May 2003 meeting, if that is the desire of the Board.

The Board believes that the DOE's commitment to "jump-starting" transportation planning and activities is imperative, in particular the DOE's recognition of the need to reactivate institutional activities to address the concerns of the State, Tribes, and affected counties.

Response: DOE believes that it is critical to "jump-start" the transportation program and agrees with the Board's observation that resumption of institutional activities is very important. To accomplish the re-emphasis on the transportation activities DOE has requested Fiscal Year 2003 funds to restart the Transportation Program. The Secretary of Energy has committed to Congress to have a transportation plan prepared by the end of this fiscal year. This plan is currently in preparation. We look forward to working with you as the plans develop on this vitally important issue. We will also, of course, support the February 25 meeting on this subject with your Panel on the Waste Management System.