



Department of Energy

Washington, DC 20585

October 17, 1997

Dr. Jared L. Cohon
Chairman
Nuclear Waste Technical Review Board
2300 Clarendon Boulevard
Arlington, Virginia 22201-3367

Dear Dr. Cohon:

This letter transmits the Department of Energy's response to the Nuclear Waste Technical Review Board's *Report to the U.S. Congress and the Secretary of Energy: 1996 Findings and Recommendations*, issued in April 1997. Our response to the Board's recommendations is found in the enclosure.

As noted in the report, the Program made substantial progress in 1996 toward key long-term goals. Despite a severe budget reduction, we built upon the Program's momentum and generated a revised Program strategy that concentrates resources on core scientific and design activities and further streamlines program management. This revised plan will allow us to prepare a license application with substantial savings compared to the costs required by the December 1994 Program Plan. Congress endorsed our plan in the conference report to the Fiscal Year 1997 appropriation, and our Fiscal Year 1998 budget appropriation supports its continued implementation.

In accordance with our plan, we have completed construction of the Exploratory Studies Facility main loop. We have also accelerated our planned construction of an east-west drift from Fiscal Year 1999 to Fiscal Year 1998, as recommended by the Board, to further enhance characterization of the site. As also noted in your report, we have continued observation and testing in the Exploratory Studies Facility and new data are being gathered at an increasing rate. In addition, design activities for critical elements of the waste package and repository facility have progressed, and we are factoring recent scientific information into the design evaluations. We recently completed nine workshops to identify modeling, testing, and abstraction issues for the performance assessment portion of the viability assessment, to reach consensus on their priority, and to plan the needed near-term task. Intensive work is underway to prepare for implementing this performance assessment.

These advances in design work, site investigations and performance assessment will enable us to complete the required viability assessment next year. While not a substitute for the site recommendation in 2001, the viability assessment will serve as an invaluable management tool by focusing the site investigation and facility design on key tasks and unresolved issues. The viability

assessment will also serve as a major informational input to the policy process and provide all parties with a common frame of reference for evaluating our work.

The Department appreciates the Board's constructive review and recommendations regarding our technical program. We look forward to continuing to receive the Board's evaluations as we pursue completion of the viability assessment and the future work beyond. If you have any questions, please contact me at (202) 586-6842.

Sincerely,

A handwritten signature in black ink, reading "Lake H. Barrett". The signature is written in a cursive style with a large, prominent loop at the end of the name.

Lake H. Barrett, Acting Director
Office of Civilian Radioactive
Waste Management

Enclosure

**Department Response to the Recommendations of
the Nuclear Waste Technical Review Board's
1996 Summary Report to the U.S. Congress
and the Secretary of Energy, April 1997**

PROGRAM OVERVIEW RECOMMENDATIONS

Recommendation 1:

A decision to locate the nation's primary centralized storage facility for spent fuel at or near Yucca Mountain should be deferred until the suitability of the site as a repository location has been determined.

Response:

The Administration is committed to resolving the complex and important issue of nuclear waste storage in a timely and sensible manner consistent with the Nuclear Waste Policy Act, sound science, and the protection of public health, safety, and the environment. The Administration believes that a decision on the siting of an interim storage facility should be based on objective science-based criteria and should be informed by the viability assessment of the Yucca Mountain candidate repository site, to be issued in late 1998.

Recommendation 2:

To the extent possible under the market-driven initiative, efforts to develop storage and transportation casks should retain the advantages (e.g., standardization) previously offered by the multipurpose canister concept.

Response:

The Program has attempted to retain advantages previously offered by the multi-purpose canister concept, such as limiting unnecessary spent fuel handling, with its concomitant reduction in occupational exposure, in framing the draft Request for Proposal (RFP) for the acquisition of Waste Acceptance and Transportation Services. To this end, the acquisition strategy includes requirements to accept canistered spent nuclear fuel (SNF) from those utilities that have placed their fuel in canisters suitable for storage and transportation. Additionally, the RFP includes performance requirements for storage of the SNF canisters at a potential licensed Federal storage facility without requiring that the SNF be repackaged. The Program is encouraging utilization of such systems in the market-driven strategy by considering the inclusion of such systems as standard waste forms under the terms of the standard disposal contracts and entertaining potential compensation for avoided costs to the Federal system associated with the use of such utility-supplied equipment. Similarly the Program intended to compensate Purchasers or contractors for the avoided costs of canisters that prove to be disposable under the U.S. Nuclear Regulatory Commission's (NRC) licensing process. The timing of such compensation would be tied to the utilization of such canisters in waste disposal packages.

RECOMMENDATIONS FOR HYDROLOGY, RADIONUCLIDE TRANSPORT AND PERFORMANCE ASSESSMENT

Recommendation 3:

Before making a determination of the suitability of the Yucca Mountain site for a repository, the Department should complete additional studies of the area west of the current exploratory studies facility, where wastes would be emplaced, to determine its geologic, hydrologic, and geochemical properties. The best way to obtain the needed information is excavation of a tunnel westward across the proposed repository block.

Response:

The Department has in its planning base additional studies which will focus on the areas west of the Exploratory Studies Facility. The Department recently undertook a planning effort to determine the feasibility of moving forward in time the schedule for these activities. The goal of this enhanced site characterization effort is to develop additional information needed to complete the assessment of site suitability. In addition to determining the specific location, alignment, length, size and cost of the drift, the detailed planning effort developed an approach for test alcoves, surface and subsurface boreholes, and other scientific investigations.

The Enhanced Characterization of the Repository Block (ECRB) 90-day Planning Effort Interim Report was provided to the Board on July 18, 1997. The Interim Report is a pre-decisional document that provides an analysis of options and possible configurations for the ECRB activity. The Department decided on August 20, 1997 to support this effort. Although Congressional FY1998 budget reductions of \$30 million have unfortunately reduced our original 1998 planned science experiments in the tunnel and alcoves, we expect valuable information to support the design and performance assessment activities to be obtained.

Recommendation 4:

The Department should make a concerted effort to ensure that future TSPAs are transparent and valid, that uncertainty is treated properly, and that any peer review of performance assessment elicitation of expert judgment is objective.

Response:

The Department agrees and is taking a new approach to ensure that the next iteration of total system performance assessment for the viability assessment (TSPA-VA) is transparent and technically defensible. This approach should enhance confidence in the analyses and help communicate the complexities of predicting system behavior to a wide range of audiences (e.g., technical peers, regulatory and oversight bodies, and decision-makers within the Department, and Congress). Specific activities include:

(1) workshops with participation by key Yucca Mountain Project scientists and engineers to ensure the completeness of models and approaches to model abstractions used in the TSPA;

(2) detailed documentation of each key process model used as input to the abstracted models used in TSPA;

(3) formal expert elicitation using both Project and external experts to assist in quantifying the uncertainty in alternative model hypotheses and parameter distributions in some of the key elements feeding into TSPA; and

(4) a participatory external peer review of the development and documentation of the TSPA-VA.

To date, the Department has conducted nine workshops on the key process models that will form the basis for the TSPA-VA. Participants in the workshops have included scientists, engineers, process model developers, performance assessment analysts, and technical managers. Observers of the workshops have included the NRC, the Board, the U.S. Environmental Protection Agency, and members of the TSPA-VA Peer Review Committee. These workshops have identified and prioritized the key issues impacting long-term performance. The workshops have also fostered an integrated, Project-wide approach to addressing these key issues.

The technical defensibility of the TSPA will depend on the process models that form the bases for the abstractions in the TSPA model. Each of the key process models is being revised and documented, including a discussion of the scientific bases (i.e., validity) of the model. It is recognized that establishing model validity in the classic sense of making a prediction and running a test or experiment to validate that prediction is not possible when very slow geologic processes are involved over large scales. As suggested by the NRC in 10 CFR 60, however, where appropriate, models will be evaluated by comparisons to in situ, laboratory, or natural analog information. Model documentation also will include a discussion of the confidence in the model, alternative interpretations, and the uncertainty in the model to making predictions for long-term performance.

For some key process models, the Department has initiated formal expert elicitation using both program and external experts. These elicitation are following the process outlined in the "NRC Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program." In addition to the Probabilistic Volcanic Hazard Assessment and the Probabilistic Seismic Hazard Assessment, expert elicitation are being conducted on (1) the unsaturated zone flow model; (2) the waste package degradation model; and, (3) the saturated zone flow and transport model.

Finally, the TSPA-VA will be formally reviewed by an external peer review body. As noted by the Board in its Report, this peer review will be a participatory peer review of developing and abstracting the process models and conducting and documenting the TSPA-VA. When the TSPA-VA document is completed, the peer review will become a more traditional "late-stage review." The final results of the peer review will be used to help develop the TSPA for license application and are expected to help the traceability and transparency of the TSPA.

Recommendation 5:

The Department should consider ways of increasing public understanding and acceptance of TSPAs. One possibility is to establish processes, modeled on the lines suggested in a recent report by the congressionally chartered Commission on Risk Assessment and Risk Management, for involving and engaging the public.

Response:

The Department will carefully consider the Board's recommendation and is already planning 1998 and out-year activities that specifically address the creation of documents and materials that communicate more

effectively to less technical audiences. The Department recognizes that communicating with the public is both a difficult and a serious responsibility, and in response to this Board recommendation has studied the 1997 "Framework for Environmental Health Risk Management" document and also the other report cited, the 1996 National Academy of Sciences/National Research Council report by their Committee on Risk Characterization.

We note that these two reports address the entire societal risk-informed decision-making process, and both emphasize the need to involve stakeholders early and meaningfully in the risk management process. The Board's report text, as well as this specific recommendation, suggest that the DOE use these reports to help define more effective public involvement processes that may aid external understanding and acceptance of TSPAs.

Appendix B of the 1996 report by the Committee on Risk Characterization suggests several methods and fairly catalogs their positive and negative attributes. The Department is currently looking at these methods and their potential applicability to building public understanding and, if possible, acceptance of the Department's future TSPAs. Several of the suggested methods may be appropriate and will receive consideration. In particular: (a) focus groups to obtain in-depth feedback from a representative citizens' group on the effectiveness of presentations in terms of scope, detail, and display techniques; (b) public meetings to explain the TSPA-VA process and results, using the presentations found to be effective in the focus groups, to inform and also to obtain feedback; and (c) interactive technology, allowing public access to, and feedback on, different levels of technical information on the World Wide Web.

In addition to these potential new initiatives, several activities are currently in progress that provide for a significant degree of "stakeholder" involvement, if the broader definition of stakeholder given in the 1997 report by the Commission on Risk Assessment and Risk Management is used to include those who have "information and expertise that may be helpful." These current activities include the series of Expert Elicitation that are supporting the definition of uncertainties for TSPA, and the TSPA Peer Review activity which has public meetings at the beginning and end of each of its six-month phases.

In order to ensure that any outreach and stakeholder involvement along the lines of the 1996 report's Appendix B are well planned and properly supported, it will be necessary to bring in appropriate expertise and resources, and to include scientists and engineers whose work is represented in the TSPA, as well as the performance assessment analysts. In addition, it will be necessary to coordinate these types of public information and feedback meetings with any broadly similar activities that may be planned in the future as part of the Department's Environmental Impact Statement development process.

DESIGN RECOMMENDATIONS

Recommendation 6:

The Department should develop and examine alternative concepts to the proposed remote underground repository operations, for example, ventilation of emplacement tunnels and shields for waste packages. Some alternatives should be developed in time for consideration in the viability assessment.

Response:

The reference design that will be used for the VA will consist of the features and concepts that will provide us with a reasonable estimate of repository performance based upon best available scientific, engineering, and cost analyses. As recommended by the Board, alternative concepts in repository design and operations will continue to be identified and may be evaluated at the time of the viability assessment. The reference design will continue to evolve until the license application is submitted based on new site characterization findings, cost considerations, operational considerations, features needed to meet licensing requirements, and technology advances. This evolution will include consideration of alternative concepts.

The current approach for the viability assessment design relies on manned locomotives to transport waste packages from the surface facilities to the entrance of the emplacement drift. A remote system is then used to emplace the waste packages in the emplacement drifts. Ventilation is maintained until the emplacement drift is full, then the drift is closed and ventilation is discontinued.

An example of alternatives to this approach being evaluated is active ventilation of all drifts to keep temperatures at or below equipment operability thresholds. A flow of approximately 5 to 7 m³/s in each drift would be needed to keep the emplacement drift temperature below 50°C. This equates to a total volume requirement of 1,000 to 1,400 m³/s for the system, which is 4-5 times that of the current design capacity. Four additional shafts, two for intake and two for exhaust, would be required to move this flow. Two additional main intake drifts, one on each side, and two additional main exhaust drifts would be needed to move the air through the subsurface, distribute it to the emplacement drifts, and return it to the exhaust shafts. The operational cost of maintaining this level of ventilation for all drifts during the entire pre-closure life of the repository could be significant.

In addition, the potential for providing shielded waste packages and continuous ventilation to allow unrestricted access to the emplacement drifts is being evaluated. The evaluation identified serious concerns regarding the reduced thermal conductivity of the waste package (thereby increasing the fuel temperature and degrading the fuel cladding), the operational impact of handling the heavier, shielded packages, and the increased cost of waste packages (\$100K to \$900K per package depending on shielding type). Additionally, increasing the size of the waste package could require larger emplacement drifts. Furthermore, the current concept of not allowing routine personnel access is expected to allow the facility to operate with lower overall personnel exposures than would a concept involving such access.

Recommendation 7:

The Department should evaluate alternative design assumptions to determine whether enhanced repository performance or improved operations can be achieved cost-effectively.

Response:

The Department agrees that the repository design should be formulated from safety, performance, operational, and cost perspectives, and that the design should not favor one feature over another without consideration of the impacts on public and worker safety and overall system cost-effectiveness. The Department believes that the present repository design is flexible and robust. It is capable of accommodating a wide range of design alternatives that will enhance repository performance or improve operations. For example, according to the Controlled Design Assumptions document (CDA, Rev. 06), the repository design is required to not preclude the addition of backfill to the emplacement drifts, if the decision to do so is made at

some time in the future. A design analysis has been completed that demonstrates the feasibility of backfilling the drifts with the current design. A number of the other design alternatives with the potential for improving performance, such as drip shields, ceramic coatings on the waste packages, and drift liners can be accommodated in the current design without making fundamental changes to the repository design. Other design features that may fundamentally impact the design include the waste package size and use of shielded waste packages. If fundamental modifications to the design are required to effectively accommodate necessary improvements, they will be employed. In summary, we are looking at design alternatives from both a performance and cost-effectiveness standpoint.

Recommendation 8:

The Department should evaluate the use of pre-cast or cast-in-place concrete tunnel liners to achieve adequate long-term tunnel support. The evaluation should consider cost and possible effects on waste isolation.

Response:

The Department is evaluating the use of pre-cast and cast-in-place tunnel liners. The current design strategy regarding ground support in the potential repository is to employ robust, full-liner systems in order to produce long-lived, low-maintenance openings. The main drifts, which will remain accessible throughout the pre-closure period, are planned to incorporate cast-in-place concrete liners. For waste emplacement drifts, where access may be limited, the plan is to use pre-cast concrete liners. Because of uncertainty regarding the amount of geologic mapping that may be required in the emplacement drifts, an option involving a temporary system of bolts and wire mesh followed by cast-in-place lining is being considered. A second issue, the potential for concrete to affect long-term performance, is being addressed by considering a third emplacement drift ground support system option—steel sets with steel lagging. As part of this evaluation of liner options, the cost of each system and the differences in costs are being developed.

The following design and testing efforts either are currently under way or are in the planning stages that address the Board's recommendation.

- The viability assessment repository design activity on ground support evaluating the use of pre-cast, cast-in-place concrete, and steel lining is in progress. The inclusion of all three options in the design analysis will minimize potential design schedule impact if subsequent evaluations indicate that pre-cast liners are not acceptable.
- A series of laboratory tests on the chemistry of concrete has been initiated. These tests, being carried out over approximately six-months, are intended to evaluate the evolution of concrete chemistry over time. The testing is focused on providing information on possible pH changes over time in order to provide input to performance assessment evaluations on the suitability of concrete for use in the emplacement environment. At a minimum, two basic concrete mix designs will be tested. This testing commenced during late Fiscal Year 1997.
- A second concrete testing program is also underway. This program is centered on assessing the effects of sustained, elevated temperatures on concrete mechanical properties. Changes in concrete strength and modulus at elevated temperatures are being observed. Of particular interest in this testing is information on the "creep" of the heated concrete under load. Two mix designs are being evaluated in this program. The tests began in the latter part of Fiscal Year 1997, and the final report is expected in March 1998.

- A third sequence of tests, still in the preliminary stages of planning, is intended to evaluate the mechanical response of different configurations of joints in pre-cast liner segments. This activity should provide input to liner design, both in the shape of joint areas and in the need for reinforcement in the joint region of pre-cast segments. This testing is currently planned as a Fiscal Year 1998 activity.
- Future cost estimating activities will include costing both the construction and operation of the sub-surface repository. Costs will be developed for all three emplacement drift ground-support options as a part of these estimating activities. These data will be available for use in comparative analyses of the options.
- The Exploratory Studies Facility Heated Drift Test, currently under construction and scheduled for startup in early Fiscal Year 1998, contains several cast-in-place sections at one end of the heated portion of the test area. The rock mass and concrete liner interaction of these lined sections should provide useful information on liner behavior at elevated temperatures.

Recommendation 9:

Given the inevitable uncertainties about repository performance, more attention to defense-in-depth (multiple, redundant barriers) is needed in the waste package and repository designs. In particular, comprehensive studies of alternative engineered barriers—such as fillers, backfill materials, drip shields, and engineered inverts—should be completed.

Response:

The Department agrees that defense-in-depth should be a cornerstone of the waste package and repository designs. DOE is evaluating design alternatives to ensure the system consists of multiple barriers with diverse properties and failure modes to accommodate a wide range of repository conditions. Defense-in-depth for the engineered barrier system can be provided by preventing conditions promoting releases to the accessible environment, mitigating those conditions, should they occur; and providing multiple barriers against unacceptable releases to the accessible environment.

The present design goals for the engineered barrier system are that it should work in concert with the natural site features, not adversely impact natural barriers, and consist of multiple barriers that can be explained and defended by analysis and testing. The Department's strategy for defense-in-depth includes: (1) identification and characterization of a family of engineered barrier system design features that could be employed in the repository; (2) systematic evaluation of performance of the repository using combinations of the design features; (3) selection of design features, such that multiple sets of features exceed performance requirements; (4) assessment of uncertainties associated with each set of design features and selection of appropriate features for design; and, (5) application of an overall margin of safety and confirmation that expected performance of the selected set of design features is consistent with the selected safety margin.

Studies have been conducted, and further studies are planned to develop information and confidence in the contribution to the defense-in-depth concept of many alternative design features. Design features currently under consideration include relying on fuel cladding as a barrier, galvanic protection of the inner wall of the waste package, ceramic coatings on waste packages, large waste packages, small waste packages, invert additives, backfill, drip shields, drift liners, point loading, line loading, and spent nuclear fuel assembly blending.