



## Department of Energy

Washington, DC 20585

September 8, 1998

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

**SEP 09 1998**

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: 1997 Findings and Recommendations*, issued in April 1998. Our response to the Board's recommendations are found in the enclosure.

As the Board noted, the Department has been focused on completing the viability assessment (VA) for a repository at Yucca Mountain, as directed by the President and Congress. The VA is a management tool for the Department and an important informational input to the policy process. Its completion this year will culminate a three-year effort by the Department to assemble the information collected during site characterization into a workable repository concept for Yucca Mountain and to focus the Program on the remaining key technical issues. Our plans call for a substantial effort after the VA to complete site characterization, to continue our design activities, and to develop and document the technical bases for a site recommendation and a license application, if the site is found suitable. As the Board has suggested, this effort will include the enhanced characterization of the repository block, long-term corrosion tests, and the drift-scale thermal test.

The Department appreciates the Board's constructive review and recommendations regarding the technical and scientific aspects of the Civilian Radioactive Waste Management Program. We continue to value the Board's feedback as we complete the VA and the additional work for a site recommendation. If you have any questions, please contact me at (202) 586-6842.

Sincerely,

A handwritten signature in black ink, appearing to read "Lake H. Barrett", with a large, sweeping flourish extending to the right.

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

Enclosure

**Department of Energy's Response to the Recommendations  
in the Nuclear Waste Technical Review Board's  
Report to the U.S. Congress and the Secretary of Energy:  
1997 Findings and Recommendations**

**Recommendation 1:**

*The Board views the Department of Energy's (DOE) work on alternatives to the reference design as a vital element in the repository program. Although much of this work will be carried out subsequent to the viability assessment (VA), the DOE should consider including, in the VA, cost estimates of alternative repository design concept and sensitivity studies showing the effects of these alternative design concepts on long-term repository performance. Work on alternative repository designs should be started now, even if it cannot be included in the VA..*

**Response:**

The Department is responding to the Board's interest in studies of alternative repository design concepts by establishing a working group to identify and evaluate major design alternatives. This effort ensures that an appropriately comprehensive evaluation of design features and alternative design concepts, including those suggested by the Board, are examined prior to selecting the reference design to support site recommendation and license application. The VA will describe the current status of the effort to evaluate design features and alternative design concepts. The VA will include sensitivity studies and costs only for a set of design enhancements for the VA reference design. The working group will address performance and cost issues for other major design alternatives after the VA

As used in the VA, design feature refers to a component of a repository system, and alternative design concept refers to a layout developed specifically to incorporate particular design features. Certain design features are somewhat independent of the actual design layout; generally, they could be implemented in almost any layout. Other design features are more dependent on the design layout. Accordingly, to realize the performance enhancement potential of these design features, a specific layout must be considered.

The VA describes design features and alternative design concepts in sufficient detail to identify the studies needed to support selection of the reference design for site recommendation and license application. This future design could be closely related to the VA reference design or an enhanced version of that design. Also, it could be one of the VA alternative design concepts, or an as yet undeveloped design concept that takes advantage of the performance potential of one or more design features.

The goal of the evaluation is to provide an acceptable repository design for site recommendation and license application. This evaluation is an appropriate precursor to any submittal of a license application, as Nuclear Regulatory Commission (NRC) regulations require comparative evaluation of alternatives to major design features that are important to waste isolation. The

Department expects to interact with the Board during selection of the reference design in the event of site recommendation and license application to ensure that the Board's views are addressed.

Related to the Board's recommendation on alternative designs, the Board's report presented five questions related to the reference underground design, expressed concerns related to the waste package on galvanic protection and waste package fabrication, and suggested reconsideration of several concepts for surface operations. These issues are addressed below:

*Underground Facilities Alternative Designs and Reference Designs*

1. *Why should the diameters of the emplacement drifts be 5.5 m?*

Selection of the 5.5-m excavated emplacement drift diameter for the reference VA design resulted from the following major considerations. The drift diameter had to:

- accommodate the largest waste package dimension (approximately 2.0-m diameter) as well as the heaviest (154,000 lbs);
- provide an adequate operating envelope for a gantry (waste package carrier) to transport waste packages over the largest emplaced waste package, if necessary;
- provide for ground support systems up to 200-mm-thick and an invert. Even if no full circle lining were planned, any use of steel sets for occasional bad ground would require approximately the same clearance as that needed by the liner;
- meet the thermal goal of 200° C rock wall temperature and 350° C waste package core temperature with waste packages that have initial heat output as high as 18 kW.

Based on these considerations, a minimum of 5.1-m clear envelope was developed. Adding the 200-mm for lining, the excavated diameter is 5.5-m. Recent analysis indicates that the 5.5-m emplacement tunnel may not allow sufficient tolerances and operating envelopes. Providing the needed tolerances may cause a slight increase in diameters (~100 mm). However, the need to carry a waste package over another waste package will be reevaluated in a future analysis, which could change the requirements for drift size.

Since the existing diameter is required primarily by the gantry and largest waste package, any significant reduction in drift diameter could require a significant reduction in the largest waste package size and thermal output, a change in the emplacement mode, and elimination of backfill as an option. Alternate emplacement delivery systems such as railcars, which could allow a smaller diameter, may be employed and will be evaluated. Previous designs which used railcars indicated high costs and perceived difficulties with retrieval for that design.

The option of a small diameter emplacement drift is planned to be evaluated as a part of the design alternatives study. In that evaluation, the issues of drift stability, type of ground control system necessary, ease and cost of construction, compatibility with the waste package dimension

and weight, emplacement delivery systems, ventilation and other functional objectives will be evaluated.

2. *Has the potential effect of the exhaust drift underneath the repository on the long-term performance of the repository been evaluated?*

No detailed evaluations have been made of the potential thermal and thermomechanical effects on repository performance of the exhaust drift underneath the repository. The location of the exhaust main beneath the center of the emplacement area, and the slight slope of the emplacement drifts from the center down to the edges means that little or no water can drain from the emplacement drifts to the exhaust main. Thus, the exhaust main should not accumulate water from the emplacement drifts nor act as a fast path. While the non-thermally perturbed hydrologic effect of the exhaust shaft seems small, the thermal-hydrologic system has yet to be evaluated. The long term effects of an exhaust main beneath the repository level will be the subject of a future study.

3. *Is the value added by the exhaust drift worth its cost and potential effects, if any, on long-term performance?*

A central exhaust main is located below the emplacement drifts, midway between the east and west mains, and connects the mains located at the north and south ends of the repository block. The central exhaust main is used primarily for ventilation of the emplacement drifts and has the following values:

- It effectively reduces the total emplacement drift lengths by one-half allowing emplacement operations from both east and west mains;
- It provides better logistics for emplacement operations to accommodate the thermal load management requirements, and improves the reliability of waste package transportation within the emplacement drifts by reducing the transportation distance to one-half of the total east-west drift length;
- It allows faster cool-down of any emplacement drifts, if re-entry is needed.

The Department considers that these values, which enhance the operation of the subsurface facilities, make the exhaust main worthwhile.

4. *Have the DOE's plans provided for the funds and time that will be needed to develop, demonstrate, and license the equipment, sensors, communication devices, etc., required for remote operations?*

The use of remotely controlled transportation and emplacement equipment significantly reduces worker exposure to radiation. It also reduces shielding needed to meet health and safety requirements. Remote systems are not planned to perform any drift maintenance. If such work is necessary, the drift will be cooled by ventilation, waste packages will be removed from the drift and placed in an empty drift, and work will be performed with personnel access in the drift.

The reference VA design utilizes remote systems that are based on proven technologies, not on technologies to be developed, and are expected to function safely and reliably under the anticipated radiation and thermal conditions in the repository operations area. However, because these technologies will be uniquely applied, designers are striving to keep the applications as simple as possible.

The Project's plans include a mock-up and testing program to demonstrate functions of the remote system. The remote equipment and the communications systems by which it is controlled will both be the subject of a significant test and evaluation program.

The evaluation of alternative designs will include at least one alternative in which the waste packages are emplaceable by on-board human operators and the emplacement drifts remain accessible throughout the pre-closure period.

5. *Why are the benefits of continuous ventilation of all drifts not being taken advantage of in the current design?*

Repository ventilation studies demonstrate that increased ventilation rates can remove both heat and water vapor from the emplacement drifts. However, there is not yet significant evidence to indicate that a strategy of aggressive continuous ventilation will lead to better long-term performance. The current Project strategy is to maintain high temperatures around the emplacement drifts in order to drive away water and keep the waste packages dry as long as possible. The upcoming design alternatives analysis, which will include performance assessments, will evaluate continuous ventilation at higher levels than currently shown in the reference design.

*Galvanic Protection and Waste Package Fabrication*

As suggested by the Board, the total system performance assessment (TSPA) for the VA does not take credit for galvanic protection. This is based mostly on the fact that the corrosion-allowance barrier (carbon steel) will degrade principally by general corrosion and not by localized corrosion. In this case, galvanic protection is less effective. The only concern, which is being addressed with ongoing testing, is the potential for high aspect ratio pitting corrosion of the carbon steel by high pH water that results from interaction of groundwater with high pH concrete utilized for the drift liner surrounding the waste package. In this case, galvanic protection may be significant because the throwing power of the galvanic current from the carbon steel would be able to cover the exposed area in the corrosion-resistant material at the base of the pit. Exposure of galvanic couples between carbon steel and corrosion-resistant materials as well as drip tests are underway. These tests should provide information on the nature of the attack and the throwing power of the carbon steel. The results would also indicate whether credit for galvanic protection can be taken for the license application.

On the Board's concern about integration between the performance assessment and engineering groups, the performance assessment staff are using a design baseline in completing TSPA-VA to ensure that the design assumptions for galvanic protection in performance assessment are

consistent with the engineering design assumptions for analyses addressing corrosion of the inner barrier. This formally controlled process is structured to avoid disconnects between engineering design and performance assessment.

The concerns expressed by the Board on residual stress from shrink-fitting of the two cylinders constituting the inner and outer waste package barriers are understood and are being investigated. Shrink-fitting is being considered for ensuring that the two cylinders do not move relative to each other, in addition to its potential benefit for providing some galvanic protection of the inner barrier. Shrink-fitting has been demonstrated to be a viable method of assembling two barriers in close mechanical contact. This has been proven by the fabrication of two mock-ups and is being used in industry routinely. It is at this time considered to be the easiest and most cost-effective method to achieve the required mechanical requirements. However, other methods will be evaluated before a final manufacturing method is selected. These evaluations will consider stresses, potential crevices, point loading from shifting centers of gravity, reliability of the fabrication and inspection processes, and cost.

The Board's concerns on the inspectability of final closure welds will be fully addressed before selecting the final fabrication and welding processes. The inspection by ultrasonic testing of the inner barrier on the Fiscal Year 1997 waste package mock-up was successfully accomplished. The inspectability of the inner weld by remote ultrasonic testing will be further investigated during Fiscal Year 1998.

### *Surface Facility Operations*

The Board suggested that the Department reopen studies of multi-purpose canisters and other concepts where preparations at utilities could reduce handling of fuel assemblies and costs. The Department believes that the concept of multi-purpose canisters has merit. While the Department initiated the design and development of a multi-purpose canister system, the private sector has since embraced this activity. The Department does not plan to fund additional studies but will consider multi-purpose canister systems proposed by the private sector in response to our market-driven approach to transportation. The Department will also consider sharing any disposal cost savings from the use of a multi-purpose canister.

The Board also suggested that the Department reexamine the basis for the peak annual emplacement rate based on a concern that the waste handling facilities were being designed for a peak emplacement rate of 4,500 metric tons of uranium (MTU) that is significantly higher than the average rate of 3,300 MTU. The Department understands the concern that the waste handling facilities are cost drivers and the size of these facilities is sensitive to emplacement rate. The current design can annually process about 380 commercial spent nuclear fuel (SNF) waste packages (3000 MTU), 100 glass waste packages (250 MTU), and 70 DOE-owned SNF waste packages (50-150 MTU). This results in a peak annual emplacement rate of 3300-3450 MTU, which is comparable to the average rate of 3300 MTU and is a reasonable basis for design.

**Recommendation 2:**

*The DOE should estimate and disclose the likely variation in doses for alternative candidate critical groups characterized by different locations, ages, and lifestyles. In particular, potential doses to children should be compared with doses to adults within each candidate group.*

**Response:**

The Department recognizes the Board's concern regarding dose estimates to children. At this time, there are no U.S. Environmental Protection Agency (EPA), NRC, or Departmental radiation protection standards that specifically include children. Current regulatory practice is to estimate doses to a hypothetical representative adult, known as the Reference Man, using physiological parameters developed by the International Commission on Radiological Protection. The dose conversion factors estimated based on the Reference Man have uncertainties that are comparable in magnitude to the uncertainties in exposure assessments and to the estimates of cancer risks.

For purposes of radiation protection, the Department agrees with the EPA and the NRC that the assumptions exemplified by the Reference Man adequately characterize the general public, and a detailed consideration of factors, such as age and sex, is generally not necessary. As the Board is aware, estimating doses to children and other age-specific groups is a complex task because of factors such as systemic biokinetic models, gastrointestinal uptake factors, organ masses and positions, and food consumption habits, all of which change as a person ages.

The Department, however, will conduct a preliminary evaluation of the impact to children and other age groups and will report the results of that evaluation in a technical report, recognizing that the development of age-dependent dosimetric and biokinetics models is an ongoing international effort. The report will reflect currently available information, which may not fully address age-specific differences in some biokinetic parameters.

The concern about doses to children should be considered in light of the assumptions used in performance assessment for future populations. We assume, consistent with internationally accepted recommendations, that characteristics of the population tens of thousands of years in the future are similar to those of the current population, because we cannot reasonably forecast changes in characteristics of the population. This assumption has a large uncertainty and means that dose calculations indicate the range of likely performance of a repository for only a hypothetical population. As such, the doses should be viewed only as an indicator or figure of merit for repository performance. This indicator should be viewed in a different perspective from that for potential doses from currently operating facilities, where the characteristics of the population are known.

**Recommendation 3:**

*The DOE should evaluate the need for site-specific data for supporting the biosphere modeling needed for license application, especially soil-to-plant transfer factors. The evaluation should*

*include an estimate of the length of time over which measurements of such parameters would be needed to produce a reliable data set. Plans for obtaining the necessary data should be developed now.*

**Response:**

The Department appreciates the Board's conclusion that our approach to biosphere modeling seems appropriate and agrees that generic biosphere data will be adequate for many aspects of the modeling. The Department will continue to examine sources of uncertainty in the modeling, including the use of generic versus site-specific data. As recommended by the Board, an evaluation of using generic soil-to-plant transfer factors, or concentration ratios, has been initiated and is nearing completion.

This evaluation indicates that the values reported in the scientific literature for concentration ratios vary widely for several reasons. As the Board suggests, some of this variation is due to site-specific environmental conditions such as soil composition and texture. However, experimental procedures also contribute to the variation. For example, depth of sampling, sample preparation protocols (e.g., washing, cooking, and plant part versus whole plant analysis), pot versus garden experiments, plant species, and management practices (e.g., fertilizer, irrigation rates, and plowing) all influence experimental results. Therefore, the variation in reported values represents variations in both site-specific environmental conditions and experimental procedures.

The Department has been using generic concentration ratios published by the International Atomic Energy Agency (IAEA), because they were developed based on a critical review of existing scientific literature and data contributions from scientists generally using standardized experimental procedures. Although the use of generic concentration ratios does not appear to be the most important source of uncertainty in the biosphere modeling, the Department will continue its evaluation of generic versus site-specific concentration ratios for Amargosa Valley. In addition, we will continue to evaluate the applicability of the IAEA database to the Amargosa Valley, including the use of subsets of this database, which may be more relevant to the Amargosa Valley.

**Recommendation 4:**

*The DOE should make full and effective use of the expert elicitations, both as direct input to performance assessment and design and for the technical insights provided. The DOE should provide a rationale for the way it intends to aggregate the views of different experts and how the individual views of the experts will be treated in performance assessment. The DOE should also consider developing guidelines on how the results of expert elicitations will be treated in light of new data.*

**Response:**

The Department agrees with the Board on the value of expert elicitations. The application of the elicitations spans a range from direct use of aggregate Probability Distribution Functions to qualitative insights. For instance, the elicitations have provided direct inputs to TSPA by quantifying the range of infiltration rates applied to the surface of Yucca Mountain, the range of degradation rates of the corrosion-resistant inner waste package material C-22, and the range of effective dilution likely to occur in the saturated zone. In other cases, the elicitations have identified conceptual issues that have generally been addressed in sensitivity analyses, such as the range of conceptual models to describe unsaturated zone flow and transport, the range of alternative conceptual models used to determine the seepage into drifts, and the range of cladding degradation conceptual models. In cases where only one or two experts provided an assessment (e.g., microbiologically influenced corrosion), the elicitations usually required specialized knowledge, and the expert's opinion was only used for insight and/or input to sensitivity analyses. Yet another use of the expert elicitations has been to identify types of information that could be used to reduce the uncertainty in key components of TSPA.

The Department has developed quality assurance (QA) requirements and implementing procedures for the conduct of expert elicitations. These QA requirements and procedures for expert elicitations require documentation of the individual expert assessments and the process of aggregating their assessments, if the views of different experts are aggregated, and include guidelines for reevaluating the results of expert elicitations in the light of new data. For example, current Project plans include an activity for each fiscal year to identify new data that are relevant to the volcanic and seismic hazard analyses, such as the recent geodetic data across Yucca Mountain. The effect of these data on the results of the probabilistic volcanic and seismic hazard analyses will be evaluated if analyses, such as sensitivity studies, indicate that the effect may impact the hazard assessments.

The requirements and procedures reflect guidance provided by NRC in its *Branch Technical Position on the Use of Expert Elicitation in the High-level Radioactive Waste Program* (NUREG-1563). In meetings and correspondence, NRC has indicated that the Department's approach is in conformance with the NRC guidance and has closed numerous open items related to the Department's use of expert judgement.

**Additional Board Comments**

The Board's report raised issues beyond those captured in the four recommendations. Where these issues relate to topics in the recommendations, the Department's responses also address the related issues. Additional issues, concerning the environmental impact statement and transportation, are addressed below.

## *Environmental Impact Statement (EIS)*

The Department welcomes the Board's interest in how the EIS will explore alternative designs and characterize the "no-action" alternative. The Department, as part of its ongoing design activities, is developing design alternatives for the repository and the engineered barrier system. We are preserving flexibility in the existing design approach to ensure that design alternatives now foreseen, as well as those that may emerge with advancements in technology, can be accommodated in the repository development process. We expect that design alternatives will continue to evolve and be evaluated throughout repository licensing, construction, and operation. Input from the Board, the NRC, and other interested parties will be important as design decisions are made.

We agree that the EIS process is an appropriate venue for exploring the potential environmental impacts of design features and alternatives. We believe that the ongoing design activities that will be discussed in the VA will represent a range of reasonable design alternatives, including those alternatives recommended by the Board for consideration. In the EIS, we intend to bound the environmental impacts for the full range of designs by analyzing the impacts from the EIS implementing design alternatives (i.e., three different thermal loads).

To ensure that the impacts from the range of designs are bounded by the thermal load implementing alternatives, a study is being conducted as input to the EIS. If significant environmental impacts are not bounded by the implementing alternatives, additional analysis will be performed. With this approach, we intend to provide sufficient analyses to encompass most design features and alternatives.

The Department recognizes the importance of characterizing the impacts from the "no-action" alternative and currently is considering how best to characterize the scope of the "no action", alternative. In making that decision, we will be mindful of the Nuclear Waste Policy Act's directive that the EIS need not consider alternative sites, the need for and time of availability of a repository, and alternatives to geologic disposal.

## *Transportation*

The Department agrees with the Board that institutional issues related to transportation may require as much or more time to resolve as developing the physical infrastructure. The Office of Civilian Radioactive Waste Management works with other elements of the Department as they address such institutional issues as transportation planning, routing, emergency preparedness and training, and technical assistance for near-term radioactive materials shipments. The Department has been addressing these and other issues in preparation for the operation of the Waste Isolation Pilot Plant and for the foreign spent fuel shipments. These institutional issues have been recognized in our recent interactions with a broad range of stakeholders.

For example, we have issued core planning and policy statements for stakeholder comment. We issued a revised draft policy on April 30, 1998, for Safe Routine Transportation and Emergency Response Training, which defines policies for providing technical and financial assistance to States and Native American Tribes approximately four years prior to the start of shipping. The technical and financial assistance is a Department responsibility under Section 180c of the Nuclear Waste Policy Act. Our market-driven approach to transportation, for which the Department issued a revised draft Request for Proposals in November 1997, addresses the Department's and transportation regional service contractors' institutional responsibilities with regard to planning for emergency response, training, and public information. Institutional coordination with States and Tribes under the market-driven approach is intended to begin three to five years before the start of shipping. Our recent efforts related to Section 180c and the market-driven approach to transportation provide a working foundation for the Department to complete its transportation preparations and resolve remaining issues with affected stakeholders consistent with the planning basis for multi-year development and operation of the radioactive waste management system in 2010.

Concerning the need for full-scale testing of casks, the Department will continue to follow and comment on any related action by the relevant regulatory agencies. The use of dedicated trains, along with other rail safety and operations related issues, are being addressed through the Department's continuing dialog with the Association of American Railroads, the Federal Railroad Administration, and the rail industry for this Program, as well as through other Departmental transportation activities.

We are confident that transportation institutional issues will receive amplified attention and resolved once the decision regarding site recommendation has been made..