



## Department of Energy

Washington, DC 20585

September 30, 1992

Dr. John E. Cantlon  
Chairman, Nuclear Waste Technical  
Review Board  
1100 Wilson Boulevard  
Arlington, Virginia 22209

Dear Dr. Cantlon:

This letter transmits the Department of Energy's responses to the Nuclear Waste Technical Review Board's recommendations made in its Fifth Report to the U.S. Congress and the U.S. Secretary of Energy that was issued on June 3, 1992. Our responses to the Board's 15 recommendations may be found in the enclosure.

I am pleased to note that the program has continued to make significant progress since your previous report. As noted during our recent meetings, we are presently conducting expanded site evaluation work including the dry drilling of deep test holes with the LM-300 drill rig. During the coming fiscal year, we expect to start the site preparation work for the construction of the Exploratory Studies Facility with the goal of beginning first ramp construction in October 1993.

It is my hope that with the synthesis of data obtained during site characterization we can begin to resolve some of the basic site suitability questions surrounding the Yucca Mountain site. The resolution of these issues is paramount to an efficient and cost-effective program and the successful completion of the mission of the Office of Civilian Radioactive Waste Management.

I appreciate the Board's constructive review of our work and recommendations concerning the critical technical issues facing the program. I believe that the Board, as an independent body of renowned scientists and engineers, can help assure the soundness and quality of the program. I would like to thank you and the Board for your effort, and I look forward to continuing our mutually beneficial interactions in the future.

Sincerely,

John W. Bartlett, Director  
Office of Civilian Radioactive  
Waste Management

Enclosure

**DOE Response to the Recommendations of the  
Nuclear Waste Technical Review Board in Its  
Fifth Report to the U.S. Congress and the U.S. Secretary of Energy  
June 1992**

## INTRODUCTION

The Nuclear Waste Policy Amendments Act of 1987 established the Nuclear Waste Technical Review Board to evaluate the technical and scientific validity of activities undertaken by the Department of Energy (DOE) in the Office of Civilian Radioactive Waste Management (OCRWM).

The Board is required to report, not less than two times per year, to the Congress and the Secretary of Energy, its findings, conclusions, and recommendations. The Board has issued five reports to date. The fifth report, issued on June 3, 1992, includes 15 recommendations in 5 broad areas: (1) the systems implications of thermal-loading; (2) geoengineering; (3) tectonic features and processes; (4) the engineered barrier system; and (5) transportation and systems.

These recommendations and DOE's responses are presented in this report. Each recommendation is quoted verbatim from the Board's report of June 3, 1992, and is followed by the response.

## SYSTEMS IMPLICATIONS OF THERMAL-LOADING

The following recommendations concern DOE's selection of a thermal-loading strategy for the potential repository at Yucca Mountain and the implications of such strategy for the other elements of the waste management system.

### **Recommendation 1:**

*The Board recommends that the DOE thoroughly investigate alternative thermal-loading strategies that are not overly constrained by a desire to rapidly dispose of spent fuel. This investigation should involve a systematic analysis of the technical advantages and disadvantages associated with the different thermal-loading strategies. An assessment of each strategy's implications for other elements of the waste management system also should be undertaken.*

### **Response:**

Although DOE has not selected a final thermal-loading strategy for the potential repository at the candidate Yucca Mountain site, it has a reference strategy outlined in the Site Characterization Plan. DOE is currently investigating a range of alternatives including both "cold" (below the boiling point of water) and long-duration "hot" (above the boiling point of water) strategies. A team led by the Management and Operating contractor (M&O), and including principal investigators from Sandia National Laboratories (SNL) and Lawrence Livermore National

Laboratory, is conducting a study to ensure that the impacts of each strategy on all components of the system, from the acceptance of waste at the reactor sites to the emplacement and subsequent monitoring in a repository, are thoroughly analyzed.

The study will also determine for each thermal-loading alternative the effects on the utilities, on the design and operation of the Monitored Retrievable Storage (MRS) facility, and on the transportation system. For example, impacts being assessed include to what extent spent fuel selection at the reactor sites would be required both with and without an MRS, and the duration of above-ground storage required for each potential thermal-loading strategy. The results of the study will be reviewed by scientists and engineers who are knowledgeable of, and responsible for, the design of the engineered barrier system and the repository.

The ability to efficiently dispose of spent fuel is but one of several major considerations in the analysis of any of the strategies. The major considerations in the selection of a thermal strategy include:

1. Duration of time before aqueous corrosion of the waste packages could allow a potential release of radionuclides.
2. Avoidance of additional uncertainties in the performance assessment of the engineered barrier system and hence in the licensing process.
3. System implications of cooling spent nuclear fuel for long periods before disposal in a repository.

## **Recommendation 2:**

*In assessing the different thermal-loading strategies, it is critical that special attention be paid to evaluating the uncertainties and, in particular, the critical hypotheses associated with each strategy. The Board strongly encourages the DOE to review its research plans to ensure that this evaluation be carried out through a balanced combination of modeling, field-mapping, laboratory testing, long-term, large-scale underground testing, and, if appropriate, the study of natural analogues. This information could then allow the timely selection of a prudent thermal-loading strategy.*

## **Response:**

DOE has reviewed in the past and will continue to review its research plans to ensure that a defensible licensing basis can be achieved for the selected thermal-loading. The site characterization program will be modified as appropriate to support maturation of design and performance assessment activities related to the development of thermal-loading strategies. Areas of site characterization that will address the impact of thermal-loading on various elements of the repository system include geomechanics, geohydrology, geochemistry, and mineralogy. Evaluations of the impact of thermal-loading on the waste forms, the engineered barrier system, and the natural barrier system are also planned.

The strategy is to develop models and perform laboratory studies and long-term, full-scale underground tests such that these activities will provide data over a range of thermal conditions, leading to a decision on the general range of repository thermal loading for more detailed

evaluation. Underground testing plans will be revised where necessary to primarily address the selected thermal-loading range. Data necessary to evaluate system response at different thermal loadings within the selected range will be monitored and evaluated as the studies and tests progress. Final selection of the specific repository thermal loading will involve iteration of the site characterization program with design and performance assessment activities, and long-term, full-scale underground tests.

### **Recommendation 3:**

*Since thermal loads lower than those proposed by the DOE's reference repository design could require the use of expansion areas adjacent to the proposed 1,520-acre repository site, any exploratory work in these expansion areas should be conducted with deliberation to avoid disqualifying the areas for potential use later on.*

#### **Response:**

Strictly speaking, the use of lower thermal loads would not require the use of expansion areas, but instead may result in the emplacement of less waste in the potential repository should the site be found suitable. In any case, DOE has adopted a conservative approach to all site characterization activities that occur inside the controlled area. This area includes the conceptual repository perimeter drift surrounded by a 5 kilometer boundary. In all likelihood, potential expansion areas would be within the current definition of this boundary. This conservative approach requires that evaluations be performed prior to initiation of exploratory work. These evaluations result in controls that are designed to limit potential impacts to the site.

The activities of concern include drilling of surface boreholes, excavation of trenches, excavation of the Exploratory Studies Facility (ESF), and possible excavation of other study facilities to support the test program. The DOE processes for authorizing site characterization activities consider the impacts of the activity on the physical, mechanical, chemical, and hydrologic characteristics of the geologic entity that act individually or collectively to inhibit, minimize, or preclude radionuclide transport. Appropriate controls are specified to ensure that the site characterization activities are accomplished in a manner that limits the impacts to the site to acceptable levels.

### **Recommendation 4:**

*Care should be taken in making critical decisions, especially irreversible decisions, that could have negative implications for other components of the waste management system. This is particularly important in light of the fact that important system-wide trade-off studies have not been completed.*

#### **Response:**

DOE agrees that decisions, especially those of a critical or irreversible nature, should be taken only after careful consideration of all known and potential consequences for all components of the waste management system. As the designs of the individual elements of the waste management system mature, system design variables will be fixed. These design decisions will be based on the information available at that time, and supported by the results of the system studies.

DOE is conducting systemwide trade-off studies, as the Board has recommended, to provide a defensible, technical basis to support critical decisions. OCRWM system studies are structured to provide DOE with useful information for various possible system level decisions, addressing the resultant impacts on each system element. Evidence of this approach can be seen in the recent studies on the alternate cask and canister concepts and the system implications of thermal-loading.

Furthermore, DOE maintains close contact with the utility industry to stay abreast of their ongoing efforts. DOE plans to coordinate its efforts with those of the utility industry in areas such as the potential use of universal canisters, and the utilities' concerns and preferences regarding waste acceptance issues.

## GEOENGINEERING

These recommendations concern the Site Characterization Plan, ongoing ESF design, and conceptual repository design efforts.

### **Recommendation 5:**

*The Board recommends that the DOE avoid making design decisions for the exploratory studies facility that could preclude repository configurations shown by the proposed system studies to provide superior performance. In particular, as previously recommended by the Board, opening sizes should be as small as functionally required. The potential for using conventional rail transport should not be eliminated through the construction of tunnels with excessive grades, unless repository operational studies show the proposed design to be appropriate.*

### **Response:**

DOE agrees that the ESF configuration should not preclude otherwise advantageous repository design concepts should the site be found suitable. The evaluation of the impact of ESF design and construction activities on potential repository concepts is an ongoing process. The ESF construction work to be performed during the next year will be limited to no more than 200 feet of underground excavation at the North Portal. The locations selected for the North and South Portals are felt to be applicable to a wide range of potential ESF/repository configurations and, as such, will not present an unreasonable constraint. In any event, the location of the surface facilities is influenced more by topography, and such concerns as the extent of the flood plain, than by the exact arrangement of the underground workings.

Title II ESF design will proceed during the next 2 years based on the current Title I concept. However, close coordination will be maintained between the ESF and potential repository design. If changes in the ESF configuration that do not impact the site evaluation process are indicated by the evaluation of repository design concepts, they will be made during the normal course of ESF Title II design.

DOE is currently evaluating the ESF tunnel diameter. Evaluations to date indicate that the potential gains of smaller ramp sizes may not be justified in light of the drawbacks to the potential repository should the site be found suitable. While some savings in capital can be realized with smaller machines, advance rates are very similar for different sized machines because the larger

machines are proportionally powered. Also, muck haulage by conveyor is fairly insensitive to Tunnel Boring Machine (TBM) size because even a relatively small conveyor system can easily transport the muck from the largest TBM. Overall, there may not be a compelling advantage to reducing the current ramp sizes. Procurement actions for TBM's consistent with the final DOE decision will commence during FY1993.

The concept of using rail haulage was considered in the ESF Title I design effort (Design Analysis ST-MN-010, Rev. 3, Title I Design Summary Report). Two of the seven haulage options considered were rail haulage, with a third involving a monorail haulage system. The rail systems were discarded because of the grades involved in the ESF configuration. Even if the North ramp were to be reoriented to reduce its slope to rail grade, the ESF/repository block itself is inclined such (4+% slope in the main drift) that rail haulage would be difficult at best. Other features of underground rail haulage, such as long sweeping curves (resulting in large intersections with long tapering pillars), and operational inflexibility, make this concept less desirable than others.

Early in repository ACD a study will be undertaken to reassess the current potential repository horizon. A possible outcome of this activity could be the lessening of the gradient of the proposed repository block. If this were to occur, the viability of a rail haulage system would be enhanced, and subsequent repository transportation studies would then be conducted with these new data.

## **Recommendation 6:**

*The DOE should develop contingency plans for reduced funding levels that consider incremental approaches to excavating the Yucca Mountain block, possibly using one or two smaller tunnel boring machines, thus allowing early access across key underground geologic features.*

### **Response:**

The DOE is evaluating contingency plans and options to assure maximum efficiencies and cost effectiveness of site characterization activities that will yield the required data to make a site suitability decision with respect to disqualifiers at the earliest possible time. The DOE currently has a contingency plan similar to the one proposed by the Board. This plan would involve two tunnel boring machines, one with a diameter of 25 feet and the other of 18 feet. Underground excavation operations would start at the North Portal with the larger machine and proceed to the turnout for the North Calico Hills ramp. From this point, both machines would excavate the length of their respective levels. The two south ramps would be excavated from the bottom upward. A variant of this plan could include delaying the start of the Calico Hills ramp until the larger Topopah Spring (TS) ramp has been completed, and the TS Main Drift is excavated past the Core Test Area. This would allow excavation of the Core Test Area as early as possible.

The DOE has also developed a contingency plan to start the ESF North Ramp excavation as soon as possible. This plan would accomplish only that ESF design necessary to initiate the North Ramp excavation and utilize a leased or purchase a used TBM. Provided adequate funding is made available, the TBM can start operations by October 1993.

## **Recommendation 7:**

*The DOE should review and document the technology, practice, and experience developed by the Defense Nuclear Agency during the last 40 years for backfilling and sealing geologically contained nuclear explosions as part of its sealing program for a nuclear waste repository.*

### **Response:**

A review of the Defense Nuclear Agency's experience in backfilling and sealing underground openings has been initiated. The review is being performed by Sandia National Laboratories (SNL). This work is being performed as part of SNL's review of available technology to seal underground openings. The review will be documented in fiscal year 1993.

## **Recommendation 8:**

*Exploration work in expansion areas adjoining the proposed site should be conducted with the same requirements as those placed on the presently designated repository area, since the boundaries are not yet fixed.*

### **Response:**

DOE agrees that all site characterization activities, including both surface-based drilling and underground exploration, must be conducted under the same requirements. The current ESF Title I design does not preclude exploration outside the potential repository boundary as defined in the Site Characterization Plan-Conceptual Design Report (SCP-CDR). It simply describes a plan for characterizing the repository block as it existed at the time of preparation of the SCP-CDR.

## **TECTONIC FEATURES AND PROCESSES**

The following Board recommendations concern the investigations of the tectonic processes and geologic features at the candidate Yucca Mountain site.

## **Recommendation 9:**

*The Board recommends once again that the DOE give greater emphasis to seismic vulnerability studies. Discussions of site suitability, from the seismic point of view, should be based on the likelihood of adverse consequences and not on the occurrence of earthquake ground motion or fault displacement alone.*

### **Response:**

DOE recognizes the importance of seismic issues and has carried out seismic vulnerability studies in the past. For example, the Preliminary Design Cost-Benefit Assessment of the Tuff Repository Waste-Handling Facilities (SAND88-1600) examined the combined costs of design, licensing, construction and the consequences of failure as a function of different seismic design levels. In the coming fiscal year, at the direction of Dr. Bartlett, Director, OCRWM, seismic studies will receive a new emphasis through the initiation of a three-pronged action plan. As part of this plan,

site characterization activities related to the assessment of adverse consequences of known seismic hazards will be accelerated, topical reports will be prepared addressing the concerns of the Nuclear Regulatory Commission, and a thorough study will be carried out examining the seismic vulnerability of a potential underground repository at Yucca Mountain. The seismic vulnerability study for an underground repository will be modelled after the cost/benefit analysis for the waste handling facilities, and will weigh the adverse consequences of failure of the underground facility as a function of different seismic design levels against the likelihood of those particular consequences occurring. It is anticipated that the seismic vulnerability component of the action plan will be completed in mid-1994.

### **Recommendation 10:**

*The Board also notes that important aspects of seismic risk assessment, particularly those associated with postclosure fault displacement within the repository block, cannot be carried out until exploratory underground excavation is well advanced and faults are exposed. The Board continues to recommend that underground excavation be given a high priority.*

#### **Response:**

DOE agrees that underground access is important to assessing the potential for fault displacement within the repository block. The DOE also recognizes that a credible site characterization program must include both surface-based and underground testing. In FY1992, DOE focused on surface-based testing 1) to address site suitability issues, 2) to support environmental prerequisites, and 3) to maintain program continuity and flexibility in responding to changes in funding allocations. In FY 1993, emphasis will be placed on initiating underground access through beginning excavation of the first ESF ramp.

### **Recommendation 11:**

*As with other areas of concern, the Board recommends the DOE greatly increase emphasis on systems engineering studies. It notes that seismic issues should not be considered independently of other factors in the overall system – such as thermal-loading, drift configuration, container emplacement, nature of engineered barriers, and transportation systems.*

#### **Response:**

DOE agrees that seismic issues should not be considered independently of other factors in the overall system. As trade-off studies are carried out, impacts on the entire system will be evaluated. The selection of specific options will trigger reassessments of the need for and adequacy of site characterization activities. Modifications to the Site Characterization Program Baseline and to individual Study Plans will be made as warranted.

## THE ENGINEERED BARRIER SYSTEM

The following Board recommendations pertain to the design of the Engineered Barrier System and its contribution to overall system waste isolation performance.

### **Recommendation 12:**

*Waste package containment goals should exceed, not just meet, minimum regulatory requirements. To achieve this, the Board again strongly recommends that engineered barriers be viewed as an integral part of the radioactive waste management program, and that development and testing of robust, long-lived waste packages be funded dependably and at a level sufficient to evaluate their contribution to long-term predictions of repository behavior, and to total system safety.*

### **Response:**

DOE considers the engineered barriers as an integral part of the overall program. DOE also concurs in the need to consider engineered barrier designs that exceed regulatory requirements. DOE intends to proceed with orderly development of engineered barriers at the pace permitted by the available funding, balancing the urgency of progress in other areas of the program, such as characterizing the site.

### **Recommendation 13:**

*The DOE should increase funding to the engineered barrier system program before repository-level geologic data become available for the Yucca Mountain site. Increased funding to the engineered barrier system program after site-specific geologic data start coming in may be viewed as an attempt to compensate for site deficiencies.*

### **Response:**

DOE understands the Board's concerns regarding the funding of the engineered barrier system. Under the current schedule, the development of the engineered barrier system will be during the License Application Design phase, which is before definitive geologic data become available from the ESF.

## TRANSPORTATION AND SYSTEMS

The following Board recommendations concern the interactions and interfaces between the various components of the overall waste management system.

## **Recommendation 14:**

*The Board recommends that the DOE initiate and pursue vigorously top-level system trade-off studies so as to provide a firm, systemwide rationale for making the various major decisions that will affect the safety, efficiency, and design of the total waste management system.*

### **Response:**

DOE agrees that top-level system trade-off studies are essential in providing a firm and defensible technical basis for making major decisions at the system level. The OCRWM Systems Analysis Program has been formulated to (1) support requirements definition, document development, and concept evaluation; (2) support design decisions and system planning; and, (3) provide inputs to other OCRWM organizations such as sensitivities to design, operational, and/or policy changes; or performance criteria for inclusion in specifications.

A number of system studies are being performed, including three that cut across all systems elements: (1) System Throughput Rate; (2) Study of the System Implications of Repository Thermal-Loading; and, (3) Assessment of Alternative Cask and Canister Concepts for Storage, Transportation, and/or Emplacement. In order to specify and prioritize future systems studies, a system study planning "roadmap" is being developed to structure system-level decisions, and identify information needs associated with decisions as well as studies needed to provide the information.

DOE will use the results of these and other system studies to help make major decisions in a timely manner. These decisions are essential in accomplishing OCRWM's mission of managing and disposing of the Nation's spent fuel and high-level radioactive waste in an efficient and cost effective manner that protects the health and safety of the public and the worker, and helps preserve the quality of the environment.

## **Recommendation 15:**

*The Board recommends that the DOE develop the necessary supporting documents for the implementation of systems safety and human factors programs, including program plan and design requirements for human factors, as well as overall system safety.*

### **Response:**

DOE recognizes the importance of systems safety and human factors programs in terms of their contribution to the success of the OCRWM mission. A System Safety Plan and a Human Factors Engineering Program Plan have been drafted and are currently being reviewed. These documents provide program-level guidance regarding the implementation of system safety and human factors engineering and they describe the interfaces and relationships between program-level and project-level (i.e. system element) activities. Each project will develop a Safety Engineering Plan and Human Factors Engineering Plan. Preliminary system safety and human factors engineering requirements have been identified at the overall system level in the draft *Civilian Radioactive Waste Management System Requirements* document.