UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
1100 Wilson Boulevard, Suite 910
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April 17, 1992

The Honorable J. Bennett Johnston
Chairman
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510-6150

Dear Senator Johnston:

On behalf of the Nuclear Waste Technical Review Board, I am submitting the Board's answers to the Committee's follow-up questions, which were included with your letter dated April 7, 1992. The Board is pleased to provide the enclosed responses, which we understand will be made part of the written record of the Committee hearing held on March 31, 1992.

I would like to thank you, once again, for the opportunity to offer testimony before the Committee on several important radioactive waste management issues. We hope that the additional information contained in the answers to the follow-up questions will make a contribution to the Committee's review of the civilian radioactive waste management program.

The Board looks forward to continuing to work with the Committee, and we stand ready to provide any additional information or assistance the Committee may require.

Sincerely,

Don U. Deere
Chairman

Attachment

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Questions from the Committee on Energy and Natural Resources

1. *The Board has been a strong advocate of getting underground at Yucca Mountain as quickly as possible. What is your opinion of the decisions made to date with respect to the priorities in this program? In your opinion, has the Department developed the appropriate priorities for getting the job done?*

The Department of Energy (DOE) in its allocation of funds has given higher priority in the past to surface-based drilling and trenching than to developing the underground exploratory studies facility (ESF). The Board has been an advocate of going underground as quickly as possible, primarily so that data will be available to make *early judgments* about the suitability of the site. Excavating the tunnel declines (ramps) down to the potential repository level will provide greater exposure to the critical geologic features and will provide a better understanding of the Yucca Mountain block than can be achieved through surface-based drilling alone. Once underground, extensive data can be gathered on geochemistry, geohydrology, and geoengineering, which will be crucial for carrying out performance assessments for determining site suitability.

There are other benefits as well. The information gained underground would help the DOE to reevaluate the *scope* of the exploration and testing and to update *cost and schedule estimates for* completing site characterization.

The Board believes that both underground work and surface-based testing should proceed in parallel. The scope of such work and the rate at which it can be accomplished will, of necessity, be determined by the funds available and the established milestone dates.

The Board would like higher priority placed on other aspects of the program, for example, on issues relating to repository design, such as the *thermal-loading strategy* and the provision for *long-lived engineered barriers.* Although the DOE recognizes the importance of these two program elements, they have not been adequately funded. The Board believes that the DOE should refocus its efforts on these areas *now,* so that both the thermal-loading strategy and the potential contribution of long-lived engineered barriers can be included in overall system-performance studies.

2. *The Technical Review Board was very involved in the decision to change plans for construction of the underground facility at Yucca Mountain. Could you explain to the Committee your perspective on the decision to change from shafts to ramps? What can be accomplished otherwise? Does this shift mean that we have wasted all of the money that went into planning for the exploratory shafts?*

After evaluating the DOE's original design for the ESF, the Board recommended using ramps excavated by tunnel boring machines (TBM) instead of vertical shafts excavated by the drill-and-blast method. Also, the Board considered the number of exploratory drifts in the DOE's original plans to be insufficient to answer questions relating to site suitability and the potential presence of disqualifying features. Therefore, we recommended the excavation of additional exploratory drifts (tunnels) at the repository level and within the underlying Calico Hills unit.

Although the overall costs for ramps is greater than for shafts, the use of ramps would provide several advantages in the Board's view. Using TBMs, ramps can be excavated at rates of 50-100 feet per day, versus the 10-15 feet per day for shaft excavation. As a result, the cost of excavation per foot is several times less for ramps than for shafts. In addition, the damage to the tunnel walls using TBM technology is minimal when compared to conventional drill-and-blast methods. The ramps would be longer than the shafts resulting in a greatly enhanced exposure of rock, which would provide scientists a better opportunity to observe the faults, the rock characteristics, the ground-water conditions, and the geologic stratigraphy and structure of the Yucca Mountain block. The Board favors early underground access, which would allow these critical features to be observed and tested in a timely fashion.

Over an 18-month period, the DOE evaluated the alternative ESF ramp proposal. The conclusion was to change to a ramp alternative. The change from shafts to ramps means that some of the funds allocated to the preliminary design work for the two vertical shafts in the original site-characterization plan could have been better spent. However, in the Board's view, the potential benefits of ramp access and additional exploratory drifts (e.g., early determination of site suitability and an enhanced appreciation of the overall characteristics of the site) will far surpass the lost time and costs of the previous design.

3. *A significant amount of money is spent in the waste program on so-called prelicensing activities and interaction with NRC. In your opinion, is this interaction necessary at this juncture? Why couldn't this be delayed until after the hole is dug?*

The Board believes that participating in prelicensing activities and interacting with the Nuclear Regulatory Commission (NRC) are the most efficient and cost-effective ways for the DOE to seek clarification of the NRC licensing requirements for a first-of-a-kind geologic repository. Because a facility of this kind has not previously been licensed anywhere in the world, details related to regulatory requirements and their implementation may have to evolve over time. The rationale for this process is strengthened when questions arise about the intent of the NRC's requirements and about the scope of the proposed studies. The Board staff and some Board members have occasionally attended and interacted at meetings between the NRC and the DOE and believe these meetings to be helpful in determining the necessary direction and scope of the DOE site-characterization and licensing studies.

It should be understood, however, that an NRC staff position on a given question does not necessarily imply concurrence of the independent NRC repository licensing board, which, during the licensing process, will examine all licensing materials and consider the testimony of outside experts and intervenors.

4. *In your opinion, is there undue emphasis on the regulatory activities at this point, or is it the appropriate amount of emphasis?*

Based on the Board's review of the technical and scientific aspects of the DOE program, the current emphasis on regulatory activities is appropriate because collected data, computations, and conclusions about site characterization and repository development must eventually be presented to the NRC during formal licensing proceedings. This material must be defensible against the emerging EPA standard, the NRC regulations, and any technical and procedural objections raised by outside experts and intervenors. These regulatory activities are especially important since no organization or entity, including the DOE, has ever before applied for a license to construct a geologic repository for high-level radioactive waste.

5. *The Department's current schedules envision a decision on the suitability of the Yucca Mountain site and submission of a license application to NRC in 2001. Does this mean that we will not know until 2001 even if the site is unsuitable? How can this program be structured better to ensure that disqualifying factors are discovered as early as possible?*

Given the DOE's current schedule for completing the ESF, the determination of site suitability may not come much before 2001, the DOE's target date for license application. The Board believes that one of the DOE's primary objectives should be to determine as soon as possible, through early underground excavation and testing, if obvious disqualifying features are present at the site. Consequently, the Board has advocated that underground excavation should proceed in parallel with surface-based testing. Surface-based testing alone will not provide all the important information on fault zones in the geologic block and on the hydrogeologic characteristics of the site.

The DOE's schedule for site characterization and licensing assumes that the probability of finding any disqualifying conditions at the Yucca Mountain site is very low. The Board is somewhat less confident of such a finding and believes that substantial underground excavation and testing will be required to make this determination. The Board is concerned that delays in the initiation of underground excavation and testing could lead to delays in the identification of potentially disqualifying conditions. The Board therefore believes that a higher priority should be placed on getting underground as soon as possible to explore the site and perform important testing.

6. *In your opinion, what could be done to speed up the process of completing site characterization at Yucca Mountain and making an ultimate decision on the suitability of the site?*

From a conceptual standpoint, the process of characterizing any potential repository site consists of two interrelated elements, both of which should proceed concurrentfy. The first of these elements involves the search for obvious disqualifying features that can be readily identified through the early exploration and testing described previously. If no such obvious disqualifying features are found, however, there may be other characteristics of a potential site that may have a bearing on its suitability for repository development The second element is the systematic gathering of data related to such characteristics. These data will be required to make the ultimate decision with respect to a site's suitability or unsuitability, and they also will be needed for proceeding with a license application.

The combined process referred to above can proceed at Yucca Mountain with the maximum speed if two conditions are fulfilled. The first is the availability *to the program of* sufficient and predictable short- and long-term funding, and the second is ongoing prioritization of studies *by the program managers* to assure that, whenever possible, those studies that have the greatest impact on the early determination of site suitability are conducted first.

7. *Current regulations will require a judgment on the suitability of the site to isolate radionuclides for 10,000 years, How will it be possible to prove the performance of Yucca Mountain for 10,000 years? Is it possible to prove anything for that long?*

The regulatory framework has evolved during the past two decades through the efforts of the EPA and the NRC and defines the requirements for repository licensing. The assessment of long-term repository performance will be based on the analysis of scientific data and informed judgment.

Although predicting the performance of a repository at Yucca Mountain over the next 10,000 years will be a significant challenge, the Board is optimistic that adequate and reasonable technical and scientific judgments about the geologic barriers to radionuclide migration can be made to support conclusions on repository performance for 10,000 years within the current regulatory framework. Such scientific judgments could be based on (1) the recent geologic history of the Yucca Mountain region, (2) a review of the 13-million-year history of the repository block, and (3) comparisons of the Yucca Mountain site with natural geologic analogues elsewhere in the world where radionuclides have been isolated for periods far greater than 10,000 years.

Because 100 percent assurance is not possible on even short-term predictions of natural geologic processes, the Board has repeatedly emphasized that *added* confidence in long-term waste isolation can be gained by incorporating robust engineered barriers. Engineered barriers are those components of the repositoiy system that are subject to human control (i.e., the thermal load of the repository, the waste form, emplacement mode, containers and canisters, and backfill). The Board believes, for example, that a long-lived container could be manufactured with materials whose long-term performance might be more confidently predicted over thousands of years than can the performance of rock formations and hydrogeologic processes. The Board believes it should be possible to reduce overall uncertainty about a repository's long-term performance by relying on natural geologic barriers *in combination with* a robust engineered barrier system designed to isolate radioactive waste for thousands of years.

8. *Have we designed regulatory requirements for storage and disposal of nuclear waste that are so stringent that we are destined to fail? Have we designed requirements that cannot be proved? Is the existing regulatory framework too stringent? Would it be desirable to reevaluate what standards need to be met to assure protection of the public health and safety?*

At this point, the Board is not aware of any technical problems such that the proposed repositoiy or other elements of the storage, transport, and disposal system are "destined to fail" in obtaining regulatory approval. However, the regulatory framework is complex, and the data and analyses needed to ensure compliance with regulatory requirements have not yet been clearly established. Very substantial uncertainties remain to be resolved through further data gathering during the site-characterization process. The Board believes that ambiguities and potential inconsistencies in the regulatory framework need technical clarification. The appropriate level of regulatory stringency is a matter to be determined by the EPA and the NRC.

As further information and analyses are obtained, it could become clear that some proposed regulatory requirements will not be met at the unsaturated site at Yucca Mountain with the current repository design. For example, potential gaseous emissions of carbon-14 might violate the proposed EPA limit in 40 CFR 191. The consequences of this violation could be an extremely small but finite increase (a fraction of a microrem per capita per year) in radiation exposure from the atmosphere over that from carbon-14 levels naturally present from cosmic rays. Design changes in the waste-management system could allow the proposed regulatory requirement to be met, but perhaps at increased cost.

The siting of nuclear waste storage and disposal facilities remains a highly contentious issue among the federal government, state governments, and local interests. Even if compliance with regulatory requirements is achieved, determined public opposition to nuclear waste facilities is likely to persist In such a climate, it would be difficult to make safety standards less stringent unless a large majority of the public believes that such a change does not compromise their health and safety or that of future generations.

9. *Given the existing regulatory framework, do you believe we can resolve sufficiently the uncertainties about the suitability of any site? Does any particular type of site, or type of medium, give us better chances for success in resolving uncertainties, or does each bring with it some uncertainties?*

There will always be uncertainties about the long-term conditions and behavior of various rock types and formations, and different sites have their own advantages and disadvantages. This is why site characterization is so crucial to determining site suitability and for gathering data for repository design and licensing. Logically, sites with a more complex geology will likely require more extensive characterization before uncertainties about site suitability can be brought to acceptably low levels.

In addition to these initial uncertainties about the geology of a given site, and even after site characterization has been completed, there will be residual uncertainties that may never be resolved with absolute certainty. For example, we will never be 100 percent certain about the nature of future climatic changes, when they might take place, and how such climatic changes could affect the movement of water through a given geologic area. As with other large-scale construction projects (dams, subway tunnels, etc.), the mere existence of uncertainties does not necessarily mean that a site will be found unsuitable.

Existing and emerging regulatory standards and criteria will have to be met before any repository can be licensed, no matter where or in what medium it is located. To determine if a given site is suitable and to predict a potential repository's long-term performance, extensive site characterization will have to be conducted. The Board believes that with thorough site characterization, including surface-based *and* underground excavation and testing, questions about a site's suitability can be sufficiently resolved.

10. *You talk in your statement about the need for greater emphasis on engineered barriers. Could you explain this a little bit more? In your opinion, why has the Department not put a greater emphasis on this? In your opinion, will greater emphasis on engineered barriers improve the chances for successful licensing of a repository at Yucca Mountain?*

The Board has repeatedly expressed its concern about the continuing reductions in allocations to the DOE's research program on engineered barriers. Board members believe that engineered barriers have a potentially very important role to play in providing redundancy within the entire waste management system in general, and within the repository system in particular. And a robust, long-lived container, which would be a

major component in an engineered barrier system, could actually reduce the uncertainty related to the containment of radionuclides and thus could facilitate the licensing of a repository.

In the past, the DOE has listed a number of reasons for its diminishing emphasis on engineered barriers, including (1) its understanding of the NRC regulations, which were originally interpreted as not allowing credit for waste package life beyond 1,000 years, (2) budgetary constraints, and (3) the priority given to other aspects of the program (e.g., site characterization because of the Secretary's dual goals of receipt of spent fuel by 1998 and disposal by 2010).

The Board believes, however, that a redundant, multibarrier, defense-in-depth approach will be necessary to establish acceptably low levels of uncertainty for successful licensing of, and full public confidence in, a geologic repository. Investigating the potential of engineered barriers should proceed as part of the total design of the repository and waste-management system. Postponement of such investigations could mean that the technology and engineering design will not be available when needed.

11. *At the hearing, you made the recommendation that a policy decision be made to delay the final closure of the repository and to provide for a 100-year period for monitoring its performance prior to any decision on closure. Please explain what the benefits of such an approach would be. How would such a policy shift change the regulatory framework and requirements for determining the suitability of the Yucca Mountain site? How would such a policy shift change the costs of this program?*

The Board has not taken a position on the Canadian plan, which I referenced at the Committee hearing. This plan would allow monitoring of an open repository for 100 years leaving decisions relating to spent fuel retrieval or repository closure until the end of that period. The DOE might investigate the potential advantages of such an approach, the most obvious of which is its potential for a technically more sound and better-informed decision about closure. Future generations will have the experience gained from 100 years of monitoring as well as new technologies to factor into the decision-making process.

There could be other advantages. The requirement for backfilling as the waste is emplaced could be eliminated, resulting in cost savings. Ventilating the repository for 100 years or more could allow scientists to achieve the most desirable temperature range in the repositoiy. Design flexibility and savings in the engineering costs associated with final closure

could be additional potential benefits. It also is conceivable that at some time in the future it will become economical to reprocess spent fuel for the recovery of uranium and other valuable isotopes.

Although delaying final closure would give a repository additional flexibility, such a facility would still fall within the existing regulatory framework and would be required to meet the same site-suitability and licensing criteria.

12. *At the hearing, the suggestion was made that if it costs $6 billion to study the suitability of the Yucca Mountain site and only $2 billion to build a repository at the site, then why not go ahead and build a test facility and see if it works. Should we be looking more seriously at an approach to nuclear waste disposal that focuses more on resolving the uncertainties as we go along rather than requiring that all uncertainties be resolved up front? Would such an approach be more rational given the first-of-a-kind nature of geologic disposal and given the difficulty in predicting the performance of anything thousands of years into the future?*

The DOE's current repository development program calls for a comprehensive, $6.3-billion characterization of the Yucca Mountain site, including extensive underground exploration and testing. Based on information collected during site characterization, the DOE would then attempt to predict the repository's performance over the next 10,000 years (long-term performance predictions are required for licensing). The predictions would form the basis both for determining the site's suitability and for a license application to the NRC. If the site's predicted performance meets existing regulatory requirements, the NRC would then issue a license for repository construction and waste emplacement.

As an alternative approach, it has been suggested that waste could be more quickly and more cheaply emplaced in an *unlicensed* "demonstration facility," and its performance monitored. (Under current regulations, without performance predictions the facility could not be licensed.) Although this approach at first appears attractive, it has numerous and significant disadvantages. First, without the extensive site-characterization data normally required to design such a disposal facility, chances increase that the integrity of the disposal site could be compromised by poor design decisions. Second, the same lack of data would preclude at the outset any kind of long-term predictions on the behavior of the "demonstration facility." As a result, the only way to verify the performance of the facility would be to monitor its performance for thousands of years, thus leaving the responsibility for safe waste management in the hands of future generations. If, at some point, the facility's performance were found to be unacceptable (due to site

limitations or an inappropriate repositoiy design, for example) the facility would have to be modified, or all of the waste would have to be removed and a new site found. Both solutions could be costly and require extensive rehandling of the waste. Finally, and even more important, it is not at all clear that the public would accept the development of an unlicensed "demonstration facility" for the disposal of commercial spent fuel and high-level waste.

In summary, developing an unlicensed "demonstration facility" for the disposal of spent fuel — were it to be accepted by the public — would be a risky undertaking, especially for such a first-of-a-kind facility that is supposed to safely isolate radioactive waste for 10,000 years.