Moving Beyond the Yucca Mountain Viability Assessment: Preliminary Views

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Chairman Jackson, Commissioners, ladies, and gentlemen, good morning. It is a pleasure to be here today. My name is Debra Knopman and I am a member of the U.S. Nuclear Waste Technical Review Board. All Board members serve part-time, and most of us have other full-time jobs. I am director of the Center for Innovation and the Environment of the Progressive Foundation in Washington, D.C. My technical expertise is in hydrology, environmental and natural resources policy, systems analysis, and public administration. With me today is another Board member, Dr. Daniel Bullen, who is director of the Nuclear Reactor Laboratory and associate professor of mechanical engineering at Iowa State University in Ames, Iowa. His technical expertise includes performance assessment modeling of radioactive waste disposal facilities and materials performance in radiological and severe service environments. Our Chairman, Dr. Jared Cohon, would have liked to be here today to make this presentation, but he is out of the country on university business. Dr. Cohon sends his regrets.

Let me begin by briefly summarizing who we are and what we do. The Nuclear Waste Technical Review Board was created by Congress in the 1987 amendments to the Nuclear Waste Policy Act and is charged with evaluating the technical and scientific aspects of the Department of Energy's (DOE's) high-level nuclear waste management program. This includes site-characterization activities at Yucca Mountain and activities relating to the packaging and transport of high-level radioactive waste and spent nuclear fuel. The Board is an independent agency within the federal government, *not* part of the DOE or any other agency. The Board has eleven members who are nominated by the National Academy of Sciences and appointed by the President. Dr. Bullen and I have served as members of the Board since January, 1997.

Introduction

Today, you asked the Board to provide its views on the viability assessment (VA) of the Yucca Mountain site that was published recently by the DOE. We are pleased to do so, but we must preface our remarks by noting that the Board's review of the document is on-going and the preliminary views we present today may evolve as our review continues.

As you know, the purposes of the VA are to summarize the scientific information that has been collected at the site over the past 15 years, present the conceptual design of a repository and waste packages that might be suitable for the site, estimate how well such a repository would isolate wastes from the human environment, identify the additional studies (and their costs) needed to evaluate the suitability of the site and prepare a license application, and estimate the overall cost of disposing of waste at the site. The VA is an evaluation of progress on site characterization at Yucca Mountain and provides the technical basis for deciding whether to continue studying the site.

The VA is not, and was not intended to be, a determination of whether the Yucca Mountain site is suitable for development as a permanent geologic repository. The suitability decision, projected for 2001, allows for the completion of further site studies, repository design work, and analyses of repository system performance. So far, neither the Board's review of the VA nor its other reviews of the program has identified any features or processes that would automatically disqualify the site.

General Views on the VA

The VA is the most significant milestone thus far in the characterization and evaluation of the Yucca Mountain site. Many parts of the VA present cutting-edge scientific analysis in a comprehensible format. The Board commends the DOE for the successful completion of this assessment. In assembling the VA, the DOE integrated large amounts of data and analyses, established a preliminary repository design, and set priorities for work to be completed before decisions are made about site recommendation and licensing.

The process of integration has had the salutary effect of focusing the objectives of the scientific investigations. In particular, the VA highlighted the close connections between the repository design and the priority list of key uncertainties about the natural system. For example, such site characteristics as the movement of water and vapor at temperatures above boiling and the effect of high temperatures on rock stability are important only because of the VA's high-temperature repository design. In a low-temperature (below boiling point) design, these uncertainties would be less significant and might not need to be resolved for making a suitability determination.

The Board concurs with the DOE that the VA is simply a "snapshot" of current knowledge about the site that the U.S. Congress can use to make an informed decision on whether to continue to fund studies of the site. Today, we will discuss the Board's general views on the site and on the design of a repository for the site, based on our review of the VA. The Board concludes that Yucca Mountain continues to merit study as the candidate site for a permanent geologic repository and that work should proceed to support a decision on whether to recommend the site to the President for repository development. The 2001 date anticipated for this decision is very ambitious and much work remains to be completed. At a minimum, significant progress on the work identified by the Board in its November 1998 report and by the DOE in volume 4 of the VA will be required to support a technically defensible decision. The Board supports continuing focused studies of both natural and engineered barriers at Yucca Mountain to attain a defense-in-depth repository design and to increase confidence in predictions of repository performance.

Uncertainties in Repository Performance

In November 1998, the Board issued a report outlining its views on future research needed to address uncertainties about the performance of the repository system, including both the engineered and the natural barriers. The Board concluded in that report that although there are economic and technical limits to reducing uncertainties about the performance of the proposed repository system, some key uncertainties can be reduced further over the next few years through a focused research effort. The Board realizes that there always will be uncertainty about the performance of a repository far into the future and that eliminating all uncertainty is not possible or necessary. However, the Board believes that identifying important sources of uncertainty, estimating the magnitude of those uncertainties, reducing critical uncertainties, and evaluating the effects of residual uncertainties on expected repository performance are essential for supporting a technically defensible site-suitability decision and license application.

The Board notes that the VA relies heavily in some cases on the formal elicitation of expert judgment. This was necessary and extremely useful, given the lack of field and laboratory data in certain areas and the equivocal nature of some of the data in other areas. However, as the experts themselves pointed out, expert judgment should not be used as a substitute for data that can be obtained directly from site, laboratory, and other investigations. In the Board's view, every reasonable effort should be made to minimize uncertainty through repository and waste package design. Additional data then can be sought to address uncertainties, rather than relying so heavily on expert judgment to support decisions about the suitability of the site and a possible license application.

After reviewing the VA, the Board concludes that a significant amount of additional scientific and engineering work will be needed to increase confidence in a site-suitability decision and license application. Alternative repository designs should be evaluated that have the potential to reduce uncertainties in projected repository performance, thereby reducing the scope of additional necessary scientific study. Regardless of the design adopted, however, long-term scientific studies will be needed to establish a solid foundation for projecting repository performance thousands of years into the future. Let me discuss the Board's views in more detail.

Additional Scientific and Engineering Work is Needed

The DOE has spent many years (and many dollars) studying the Yucca Mountain site and designing the engineered components of a repository system compatible with the site. These efforts have produced a large amount of data, but significant uncertainties remain about the ability of the VA reference design to safely isolate radioactive wastes. In part, this is a problem inherent in extrapolating repository performance for thousands of years from data acquired over a much shorter period (years to decades). Uncertainties also are associated with specific characteristics of the Yucca Mountain site, especially the difficulty in predicting the nature of water movement through the fractured unsaturated rocks of the mountain and the possible entry of water into repository tunnels and its contact with waste packages. Uncertainties likely would be exacerbated by the high temperatures of the reference repository design, which may reduce tunnel stability, enhance waste package corrosion, and perturb water movement in ways that are difficult to predict.

Predicting the performance of the waste packages, which play a crucial role in the performance of the VA reference repository design, is a critical area that needs more study. Candidate waste package materials rely on the presence of a thin passive layer to protect the underlying metal from the oxidizing environment that will be present in a Yucca Mountain repository. Improving the basic understanding of long-term passivity is essential because, at present, there seem to be no documented natural or man-made analogs that can be used to demonstrate whether this mode of protection would persist over the desired period of time. Research also should be continued on the susceptibility of the passive layer to known modes of corrosion, especially potentially catastrophic failure modes, such as stress-corrosion cracking.

The Board believes that the scientific and engineering work completed to date, as extensive as it is, should be supplemented to improve the technical foundation for evaluating the suitability of the site or preparing a license application. The Board agrees with a DOE-commissioned peer review panel which found that two types of additional data are needed to improve the credibility of the total system performance assessment part of the VA (TSPA-VA): (1) fundamental data that are essential to the development and implementation of the models and (2) data sets designed to challenge conceptual models and test the coupled models used in the TSPA-VA. There are substantial uncertainties about the performance of a repository based on the VA reference design that can be resolved only by considering alternative repository and waste package designs and by collecting additional scientific data.

In volume 4 of the VA, the DOE has identified and set priorities for a suite of additional studies to produce information needed for repository licensing, assuming that the site is determined to be suitable for development as a repository. The planned studies include data collection, analysis, and engineering design, as appropriate, for the three major barriers discussed by the Board in its November 1998 report (unsaturated zone, engineered barrier system, and saturated zone). Among the most important are geologic, geochemical, and hydrologic studies, including those planned for the east-west cross drift. These studies are aimed at understanding the magnitude and distribution of seepage into the repository under present conditions and under past conditions when the climate was very different. They include systematic analysis of the rock samples being collected, especially for chlorine-36 and other indicator isotopes; flow and seepage tests at different locations along the drift; moisture-monitoring activities; tests in the lithophysal zones that would host the majority of waste packages; and studies of the Solitario Canyon fault, the active fault bounding the repository that also may serve as a main conduit for percolating water. Of equal importance are studies for supporting projections of the performance of the engineered barrier system, which, in the VA reference design, plays a critical role in isolating radioactive wastes for tens of thousands of years.

The studies identified by the DOE in volume 4 of the VA appear to be appropriate in the sense that they are technically feasible and are likely to produce useful information that will improve the understanding of long-term repository performance. There is no guarantee, however, that completion of these studies will lead to successful development of a repository at the site. The studies could show the site to be unsuitable, or they could raise new questions requiring further study. On the basis of current information, however, the Board is pleased that volume 4 identifies an appropriate suite of studies to be pursued in the years ahead.

The Board is concerned that some of the planned studies identified in volume 4 of the VA may be deferred because funds are not available to carry them out in a timely manner. Deferring scientific and engineering studies will delay the assembly of a more credible technical basis to support the site recommendation anticipated in 2001 and, if the site is found suitable, a license application in 2002. For the current VA repository design, a credible basis does not yet exist.

Alternative Repository Design

High temperatures in the VA repository design cause large uncertainties about how the site would behave both before and after repository closure. The Board believes that a repository design with lower waste package surface temperatures merits further detailed analyses. Such a design has the potential to reduce uncertainty, simplify the analytical bases required for site recommendation, and make licensing easier. Combined with improved waste package shielding, the design also could simplify preclosure performance confirmation by enhancing access to the tunnels, thus reducing or eliminating the need for separate performance-confirmation drifts, and permitting direct access to performance-confirmation instrumentation near the waste packages.

The following factors influenced the Board's thinking on repository design.

- Lower temperatures would significantly reduce coupled thermal-hydrologic and thermal-geochemical processes. Maintaining near-field temperatures below the boiling point of water after repository closure, by ventilation or aging, could reduce uncertainties about the movement of water and associated geochemical processes in the repository's natural barriers. This could increase confidence in the analyses of repository performance required for a site-suitability determination.

- For a given environment, chances for degradation of corrosion-resistant waste package materials would be reduced significantly if peak waste package surface temperatures were reduced.

- High repository temperatures are expected to increase the mechanical degradation of repository rocks. There is little, if any, relevant experience to draw on for predicting the long-term effects of repository heating and subsequent cooling on drift stability.

The DOE is evaluating alternative repository designs that might be appropriate as the basis for a license application, and the reference repository design presented in the VA is expected to change as the alternatives are considered. The Board strongly urges that analyses of alternatives should not be limited to "enhancements" to the reference design but should give serious consideration to true alternatives to the reference design, including a design that limits waste package surface temperatures.

Long-Term Scientific Studies

If Yucca Mountain is found suitable and construction of a repository is authorized, the Board believes there will be a need for a long-term science program to reduce uncertainties about the performance of engineered barriers and the interactions between the repository and natural processes. An important goal of these studies should be identification of unknown failure modes or unexpected evolution of natural processes that could adversely affect the performance of the major barriers of the repository. Thus, these studies may be more extensive than the performance confirmation activities now anticipated for a repository. For example, if the waste package design continues to rely strongly on corrosion-resistant metals protected from

corrosion by a passive layer, long-term scientific studies need to be carried out to improve the basic understanding of the processes that could affect the passive layer.

Long-term studies of the natural barriers also will be needed, primarily to verify projections of water movement within the unsaturated and saturated zones near the repository. For a high-temperature repository design, fundamental studies of coupled thermal-hydrologic and thermal-geochemical processes will be needed. For a low-temperature design, a less extensive program of monitoring in situ water movement may be adequate. Whether the long-term scientific studies are a decade-long program or much longer will depend in part on how the repository design evolves. There is no doubt, however, that a program of some sort will be needed to increase confidence in estimates of long-term repository performance.

Postclosure Safety Case

The ultimate goal of the studies at Yucca Mountain is to demonstrate that a repository at the site can safely isolate wastes from the human environment. The DOE proposes to demonstrate safe waste isolation through a five-part postclosure safety case consisting of the following.

- assessment of expected postclosure performance (i.e.,TSPA)
- design margin and defense-in-depth
- consideration of disruptive processes and events
- insights from natural and man-made analogs
- a performance confirmation plan.

The Board believes that this proposed strategy is an appropriate way to evaluate a Yucca Mountain repository, although each component, especially defense-in-depth and the performance-confirmation plan, requires significant additional development. Multiple lines of evidence will provide a more convincing demonstration of repository safety than will any individual component of the safety case. TSPA, including sensitivity and uncertainty analyses, is the appropriate core analytical tool of the safety case. TSPA is the analytical technique that pulls together relevant information about the performance of the repository system, determines which features or parameters could strongly influence performance, and estimates the uncertainties in projections of performance. TSPA has its limits, however, and the DOE will need to aggressively pursue the other four components of the safety case.

Judging how realistic the “bottom-line” TSPA estimates of repository performance are in the VA is difficult. In fact, a DOE presentation to the Board at its most recent meeting stated that the VA’s performance assessment (TSPA-VA) cannot be used to do the following.

- Assess compliance with regulatory criteria.
- Show defense-in-depth for the design of the repository system.
- Assess the importance of small design changes.
- Determine the suitability of the overall repository system.

Because of a general lack of data to support critical assumptions in the mathematical models, some of the assumptions in the TSPA-VA are likely to be overly conservative and others may be nonconservative. Numerous examples are presented in the recent report of the TSPA-VA peer review panel. Assessing the realism (or, at least, verifying the conservatism) of TSPA projections of repository performance is an important goal of the additional studies called for by the Board. The Board does not believe, however, that relying solely on TSPA to demonstrate repository safety will ever be possible. For that reason, the other four components of the postclosure safety strategy should be developed aggressively as complements to TSPA. An implicit or explicit sixth component of the safety strategy also should be considered: designing the waste packages and the repository to minimize uncertainties in projected repository performance.

Conclusion

The VA concludes, "… Yucca Mountain remains a promising site for a geologic repository and … work should proceed to support a decision in 2001 on whether to recommend the site to the President for development as a repository." The Board agrees that Yucca Mountain continues to merit study as the candidate site for a permanent geologic repository and that work should proceed to support a decision on whether to recommend the site to the President for development. The 2001 date anticipated for this decision is very ambitious and much work remains to be completed. At a minimum, progress on the work identified by the Board in its November 1998 report and by the DOE in volume 4 of the VA will be required to support a technically defensible decision. The Board supports continuing focused studies of both natural and engineered barriers at Yucca Mountain to attain a defense-in-depth repository design and to increase confidence in predictions of repository performance.

This concludes our prepared remarks and we will be happy to try to answer any questions you may have.