U.S. NUCLEAR WASTE TECHNICAL REVIEW BOARD

Report to The U.S. Congress And The U.S. Secretary of Energy

November 1998

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UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
2300 Clarendon Boulevard, Suite 1300
Arlington, VA 22201-3367

November 1998

The Honorable Newt Gingrich
Speaker of the House
United States House of Representatives
Washington, DC 20515

The Honorable Strom Thurmond
President Pro Tempore
United States Senate
Washington, DC 20510

The Honorable Bill Richardson
Secretary
U.S. Department of Energy
Washington, DC 20585

Dear Speaker Gingrich, Senator Thurmond, and Secretary Richardson:

The Nuclear Waste Technical Review Board (Board) submits this report in accordance with the requirements of the Nuclear Waste Policy Amendments Act of 1987, Public Law 100-203.

Congress created the Board to evaluate the technical and scientific validity of activities undertaken by the Department of Energy (DOE) for disposing of the nation's spent nuclear fuel and high-level radioactive waste, including the DOE's program for characterizing a proposed repository site at Yucca Mountain in Nevada. The Board also reviews DOE activities related to packaging and transporting spent fuel and high-level waste.

In its report, the Board evaluates information about the proposed repository system, with emphasis on the unsaturated zone, the engineered barrier system, and the saturated zone. The Board considers some of the important connections between the site's natural properties and the current designs for the waste package and other engineered features of the repository. The Board also comments on research, much of which is already under way or planned, that will be needed to support important program milestones, including determining whether the site is suitable and licensing the repository, if the determination is positive. We believe that the information in this report will be useful to policy makers and DOE managers, staff, and contractors.

The Board emphasizes that this report is *not* a review of the forthcoming viability assessment (VA) of the site. The Board plans to comment on the technical and scientific aspects of the VA after it is issued by the DOE.

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We thank you for the opportunity to serve the Congress, the Department of Energy, and the nation. We share and are committed to the common goal of furthering safe and cost-effective management of spent nuclear fuel and high-level radioactive waste.

On behalf of the Board,

Jared L. Cohon
Chairman

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Executive Summary

The U.S. Nuclear Waste Technical Review Board evaluates the technical and scientific validity of activities undertaken by the Secretary of Energy to characterize Yucca Mountain in Nevada for its suitability as a location for a repository for high-level radioactive waste (HLW) and spent nuclear fuel (SNF). The U.S. Department of Energy (DOE) plans to complete a "viability assessment" (VA) of the Yucca Mountain site in the fall of 1998. Then, under the current schedule, the DOE will advise the President in 2001 on whether the site is suitable for developing a repository. If the President accepts a positive recommendation, the DOE intends to apply to the Nuclear Regulatory Commission (NRC) in 2002 for a license authorizing repository construction.

The DOE has made considerable progress in characterizing the Yucca Mountain site and developing a comprehensible waste isolation strategy for a repository that might be located there. Plans are being made for new and continuing scientific and technical work that will be conducted following the VA to help reduce some key uncertainties. In general, the Board believes that the DOE has identified some of the key areas of research whose results would improve the technical basis for making a determination about site suitability and, if appropriate, for applying to the NRC for a license to build a repository. The Board offers its views in this report about the objectives and priorities of future research for supporting these milestones. The Board emphasizes that this report is *not* a review of the forthcoming VA. The Board intends to offer its views on the technical and scientific aspects of the VA in a timely manner after the VA is issued.

The Board realizes that at the time a decision on site suitability is made, not all uncertainties about the proposed Yucca Mountain repository will have been resolved fully. The question of how much scientific uncertainty is tolerable at the time of a suitability determination for the Yucca Mountain site is ultimately a policy question. The Board believes that its role is to identify current uncertainties associated with the overall performance of the repository system and its constituent parts, describe the technical and scientific means by which some of those uncertainties could be reduced, and estimate the approximate time at which the scientific results might be available.

The Board strongly supports continuing focused studies of both the natural and the engineered barriers at Yucca Mountain to attain a defense-in-depth repository design and to increase confidence in predictions of potential health effects in the future. Although there are economic and technical limits to reducing uncertainties, the Board believes that some key uncertainties could be further reduced over the next several years through a focused research effort. One line of work is to continue investigating alternative repository and waste package designs that could reduce the level of uncertainty about the performance of the overall repository system. Another is testing some of the important hypotheses about waste package materials under well-controlled conditions.

In this report, the Board evaluates information about the proposed repository system presented to it in meetings and other exchanges, with emphasis on the unsaturated zone (UZ), the engineered barrier system (EBS), and the saturated zone (SZ). The Board considers and comments on some of the important

connections between the site's natural properties and the current designs for the waste package and the other engineered features of the repository.

The UZ at Yucca Mountain is a critical natural feature of the repository system because it would form the roof, foundation, and interior of the repository itself. Along with structural integrity, the UZ would provide the hydrologic and chemical environment for the waste packages and would be the first natural medium through which the radionuclides, when released, would be transported by water to the SZ. The volume and geochemistry of the water that may reach waste packages, cause them to corrode, mobilize the waste, and carry radionuclides to the water table are key parameters affecting the long-term isolation of radioactive waste in a Yucca Mountain repository.

The present level of uncertainty about seepage (water entering repository tunnels) is high. Experiments that are under way have the potential to reduce this uncertainty over the next several years. Ongoing observations of bomb-pulse chlorine-36 and other isotopes at the repository horizon and at comparable settings nearby must continue to be collected and analyzed systematically. Data from experiments in the single-heater and drift-scale heater tests should provide insights into moisture movement during above-boiling thermal conditions, thus reducing thermohydrologic uncertainties. Experiments under way at Busted Butte will characterize better the transport of radionuclides in the UZ after their release from waste packages. Data from these studies will enhance confidence in conceptual models of groundwater flow and radionuclide transport in the UZ of Yucca Mountain.

Many aspects of repository design may affect waste isolation, including tunnel diameter, tunnel stability, waste emplacement mode, and use of backfill or drip shields. The EBS would play a key role in isolating radioactive waste in a Yucca Mountain repository, especially if a highly corrosion-resistant waste package material (e.g., a nickel-base alloy) is used. The DOE intends to evaluate alternative features and design concepts that may enhance performance or decrease uncertainty. Among the more important alternatives to be evaluated are lower-temperature designs that use ventilation to reduce uncertainties about the heat-induced hydrologic, mechanical, and chemical changes in the rock surrounding waste emplacement tunnels. Observations and experimental results from the Exploratory Studies Facility and the recently completed cross drift above the repository horizon may increase confidence in predictions of tunnel stability and short- and long-term performance.

Research is under way for assessing and placing bounds on corrosion rates of candidate waste package materials for repository conditions. Continuing this research is vital. Also important is continued development of waste package manufacturing methods, including quality control, inspection, and postweld heat treatment, all of which are essential for preventing early failures and extending waste package life. Long-term research will be needed to detect and control or mitigate any processes that could damage the passive layer that forms on the surface of a corrosion-resistant waste package metal and greatly retards further corrosion of the metal. In addition, the long-term phase stability of nickel-base alloys needs to be studied to identify the effects of possible phase instability on corrosion resistance.

The SZ may act as a natural barrier by (1) delaying the arrival of radionuclides at the accessible environment and (2) reducing radionuclide concentrations in groundwater, and thus dose to a critical group, through dispersion and dilution. The SZ may have a greater potential as a barrier than can be demonstrated by currently available data. The Board believes that continued single- and multiple-well testing of the type conducted at the C-well complex is necessary to bound estimates of flow-and-transport parameters on the basis of field observations. The Board also believes that continued geochemical characterization of the water in the SZ is important. Parts of the SZ may be a chemically reducing environment in which oxygen is absent. If so, some of the very-long-lived radionuclides that are sensitive to the oxidizing or reducing potential of the groundwater, including neptunium and uranium, would precipitate, permanently removing them from the groundwater and reducing predicted radiation doses at the biosphere.

The Nye County drilling project envisions 21 wells, some shallow and some deep. The drilling project, in conjunction with the proposed U.S. Geological Survey testing program, should provide data on the

three-dimensional characteristics of the regional flow system and the geochemical character of water near the tuff-alluvium interface. The flow-and-transport model should be revised as data from these new and continuing site-characterization efforts become available.

The current repository design for Yucca Mountain envisions "defense-in-depth" that is provided by both natural and engineered barriers. Uncertainties remain about the long-term performance of each barrier, and additional studies are needed, as discussed in this report. The Board strongly supports continuing focused studies of both the natural and the engineered barriers at Yucca Mountain to attain a defense-in-depth repository design and to increase confidence in predictions of potential health effects in the future.