

**ORIGINAL**  
**UNITED STATES OF AMERICA**  
**NUCLEAR REGULATORY COMMISSION**

**Title:            BRIEFING BY NUCLEAR WASTE TECHNICAL  
                  REVIEW BOARD (NWTRB)  
                  PUBLIC MEETING**

**Location:        Rockville, Maryland**

**Date:            Monday, March 30, 1998**

**Pages:          1 - 61**

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1 UNITED STATES OF AMERICA  
2 NUCLEAR REGULATORY COMMISSION

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4 BRIEFING BY  
5 NUCLEAR WASTE TECHNICAL REVIEW BOARD (NWTRB)

6 \*\*\*

7 PUBLIC MEETING

8  
9 Nuclear Regulatory Commission  
10 One White Flint North  
11 Rockville, Maryland

12  
13 Monday, March 30, 1998  
14

15 The Commission met in open session, pursuant to  
16 notice, at 2:00 p.m., Shirley A. Jackson, Chairman,  
17 presiding.

18  
19 COMMISSIONERS PRESENT:

20 SHIRLEY A. JACKSON, Chairman of the Commission

21 GRETA J. DICUS, Commissioner

22 NILS J. DIAZ, Commissioner

23 EDWARD McGAFFIGAN, JR., Commissioner  
24  
25

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1 STAFF PRESENT AND PRESENTERS SEATED AT THE COMMISSION TABLE:

2 JOHN C. HOYLE, Secretary of the Commission

3 KAREN D. CYR, General Counsel

4 JARED L. COHON, Chairman, NWTRB

5 DEBRA S. KNOPMAN, Member, NWTRB

6 RICHARD R. PARIZEK, Member, NWTRB

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## P R O C E E D I N G S

[2:00 p.m.]

CHAIRMAN JACKSON: Good afternoon, ladies and gentlemen. This afternoon, the Commission is pleased to welcome Drs. Jared Cohon, Debra Knopman, and Richard Parizek, from the U.S. Nuclear Waste Technical Review Board.

The Board members will brief the Commission on the status of their evaluation of the technical and scientific aspects of DOE's work at the Yucca Mountain repository.

The Commission is very pleased to have the three of you here.

It has been nearly two years, namely July 30th of 1996, since the Technical Review Board last briefed the Commission about the Board's activities and its perspective on the Department of Energy's program to manage high level radioactive waste.

Much has changed in that period. I recognize that the makeup of the Board itself has changed considerably in the last couple of years, but the makeup of the Commission itself is different, and that this will be the first briefing that Commissioners McGaffigan and Diaz will have had with the Nuclear Waste Technical Review Board, and all of us have been looking forward to it.

So since the last briefing, DOE has completed the 25-foot diameter tunnel into Yucca Mountain and DOE

1 continues to prepare a viability assessment for determining  
2 the technical suitability of the Yucca Mountain site.

3 Here at the NRC, the staff is developing  
4 site-specific regulations for Yucca Mountain and continues  
5 to conduct pre-application review activities of the DOE  
6 program.

7 As we are all aware, Congress currently is  
8 considering legislation that could significantly alter the  
9 existing high level radioactive waste program. It is clear  
10 that that program has been and continues to be in a state of  
11 flux.

12 The Commission believes, therefore, that this  
13 briefing is very timely is particularly interested in  
14 receiving the views of the Nuclear Waste Technical Review  
15 Board on the state of DOE's civilian radioactive waste  
16 management program.

17 So unless my colleagues have any comments, Dr.  
18 Cohon, please proceed.

19 MR. COHON: Thank you, Chairman Jackson,  
20 Commissioners. It is a pleasure for us to be here today.

21 As you heard, my name is Jared Cohon. I'm the  
22 Chairman of the Nuclear Waste Technical Review Board. All  
23 of our members serve part-time and most of us have other  
24 full-time jobs, our day jobs, as it were. In my case, I'm  
25 President of Carnegie-Mellon University and my area of

1 technical expertise is environmental water resource systems  
2 analysis.

3 Accompanying me are two other Board members who  
4 will make part of our presentation today. Dr. Debra Knopman  
5 is Director of the Center for Innovation in the Environment  
6 of the Progressive Policy Institute here in Washington. Her  
7 expertise is in hydrology, environmental and natural  
8 resources policy, systems analysis, and public  
9 administration.

10 Dr. Richard Parizek is a Professor of Geology and  
11 Geo-Environmental Engineering at the Pennsylvania State  
12 University. His expertise is in hydrology and environmental  
13 geology.

14 We will pretty much stay to the remarks that we  
15 submitted to you in advance, but we may stray from them from  
16 time to time, if you will permit us to do so. We do so in  
17 the name of time, in order to save plenty of time for  
18 discussion.

19 As you noted, Chairman Jackson, it's been some  
20 time since we briefed the Commission and had the opportunity  
21 to meet with you. In light of that, I'd like to take a  
22 moment just to acquaint the Commissioners with who the Board  
23 is.

24 We were created by Congress in the 1987 amendments  
25 to the Nuclear Waste Policy Act. We were charged with

1 evaluating the technical and scientific aspects of DOE's  
2 high level nuclear waste management program. This includes  
3 site characterization activities at Yucca Mountain and  
4 activities relating to the packaging and transport of high  
5 level radioactive waste and spent nuclear fuel.

6 The Board is an independent agency within the  
7 Federal Government. We are not part of the DOE or any other  
8 agency.

9 The Board is authorized to have 11 members, who  
10 are nominated by the National Academy of Sciences and  
11 appointed by the President. I have served as a member since  
12 1995 and became the Board's third chairman last year.

13 Drs. Knopman and Parizek were two of eight new  
14 members appointed to the Board last year. With this many  
15 new members joining the Board, as Chairman Jackson noted,  
16 we've had a very busy year playing catch-up and, I will tell  
17 you, it's been a lot of fun. This is a very active, dynamic  
18 group, a very sharp group of members that we have.

19 Today in our prepared remarks, as indicated in the  
20 slide, which I hope will appear -- this is a test.

21 [Slide.]

22 MR. COHON: As you can see, we want to emphasize  
23 certain things, things that we view as key developments  
24 during 1997, which will be the year that we focus on.

25 We will also briefly discuss our views of the

1 upcoming viability assessment, which we expect to be the  
2 focus of much of the Board's activities throughout 1998.

3 Our presentation draws heavily on the Board's 1997  
4 summary report, which we hoped would have been delivered to  
5 you before now. Unfortunately, final editing and printing  
6 of the report have taken more time than we expected, but you  
7 should be receiving the report within the next few days.

8 As I mentioned, we look forward to some collegial  
9 discussion with the Commission at the conclusion of our  
10 remarks.

11 Let me turn now to the viability assessment, which  
12 the Chairman noted in her introduction. As you know, the  
13 DOE is required to provide to the President and Congress a  
14 viability assessment, or VA, as we will refer to it, of the  
15 Yucca Mountain site, no later than September 30 of this  
16 year.

17 The VAs include the four elements shown on the  
18 slide, the repository and waste package design. I want to  
19 emphasize that's both for the repository and the waste  
20 package. Total system performance assessment; a plan and a  
21 cost estimate for the remaining work required to complete a  
22 license application; and, an estimate of the cost of  
23 constructing and operating the repository in accordance with  
24 the design concept.

25 Much of the Board's activity during 1997 involved

1 preparation to review the VA, which, in light of the Board's  
2 mission, will focus on design and performance assessment,  
3 the technical issues.

4 In 1998, we will continue our preparation and we  
5 look forward to reviewing the VA later this year.

6 Let me summarize for you the Board's current views  
7 on the four components of the VA.

8 First of all, design. The Board believes that the  
9 design activity of the Yucca Mountain project saw several  
10 major accomplishments during 1997. They include refinement  
11 of the designs for repository surface and underground  
12 facilities and for the waste package, further integration of  
13 spent fuel owned by the DOE into disposal plans, continuing  
14 studies of criticality control issues, and improved  
15 integration of engineering and performance assessment.

16 There are, however, continuing needs to adopt a  
17 more robust engineered barrier system and to thoroughly  
18 explore different integrated repository and waste package  
19 designs that may offer the promise of better performance,  
20 lower costs, reduced uncertainty, or simpler operations.

21 Let me emphasize here, we are not criticizing the  
22 design that DOE has developed. We're simply emphasizing the  
23 importance of looking at alternatives.

24 With regard to repository surface facilities,  
25 these facilities would be located on an 80-acre site at the

1 repository's north portal and would consist of more than 15  
2 structures and a small rail yard. These facilities would  
3 receive waste and package that waste for disposal.

4 Except for the final closure welds and inspections  
5 of the waste packages, the Board considers all of the  
6 technology of the repository surface facilities to be  
7 commercially demonstrated and available.

8 However, the Board does have some remaining  
9 concerns about the design basis, including questions about  
10 the assumed peak in placement rate, which may be  
11 unrealistically high; the possibility of transferring some  
12 waste packaging operations to nuclear power plant sites,  
13 with potential cost savings; and, the potential benefits of  
14 using multi-purpose canisters as part of the overall waste  
15 management system.

16 These concerns are discussed in more detail in the  
17 Board's 1997 summary report, which the Commission will be  
18 receiving shortly.

19 Let me turn now to the repository underground  
20 facilities. You will see on the monitors a schematic  
21 drawing of the proposed repository. Let me take you through  
22 this very quickly, just to acquaint, especially the new  
23 Commissioners, with the envisioned layout.

24 First, you see the repository footprint itself.  
25 That's it. Excellent. Also shown is the main access, which

1 is the same thing as the exploratory studies facility that  
2 the arrow is following right now. This is the tunnel that  
3 the Chairman referred to before, the 25-foot diameter tunnel  
4 that was dug, that was completed just about one year ago.

5 This facility, the exploratory studies facility,  
6 has been the crucial experimental facility for providing  
7 data about the mountain at the level of the repository and,  
8 in addition, as I said, it will serve as the main access,  
9 one of the main access points to the repository.

10 Also shown in this diagram is the proposed ECRB  
11 or, as the Board has referred to it in the past, the  
12 east-west drift. That proposed tunnel is intended to  
13 actually go through rock similar to the repository block  
14 itself to gain firsthand access to the environment in which  
15 the waste would be placed if this repository opens.

16 DOE is now finalizing plans and starting, I  
17 believe, the construction of that tunnel.

18 Finally, let me just point out the surface  
19 facilities referred to earlier, shown at the north portal,  
20 the beginning of the ESF.

21 By the way, this whole area is approximately 300  
22 meters below the surface of the mountain.

23 Let me point out, also, that the current concept  
24 is that the emplacement drifts -- that's an emplacement  
25 drift. The idea is that as these are dug, they would be

1 filled with waste and as filled, they would be closed off  
2 with doors, limiting human access to them.

3 Let me turn now to the waste package. The  
4 referenced waste package design is a double-shelled  
5 cylinder, nearly two meters in outside diameter and five  
6 meters long, with a two-centimeter-thick inner shell of  
7 corrosion-resistant alloy C-22 and a ten-centimeter-thick  
8 outer shell of carbon steel, a corrosion allowance material.

9 The waste package will be emplaced on its side on  
10 pedestals in the emplacement drifts. Data obtained from the  
11 exploratory studies facilities, which you just saw on the  
12 slide before, within the last two years, clearly show that  
13 the repository will be wetter than thought as recently as  
14 just three years ago.

15 This discovery has triggered examination of  
16 enhancements to the existing design. Examples of such  
17 enhancements are drip shields that keep water off the  
18 packages and backfill. The Board is particularly interested  
19 in seeing studies of additional design options that might  
20 include smaller shielded waste packages, a waste package  
21 design using two corrosion-resistant materials rather than a  
22 corrosion-resistant and corrosion-allowance material, and  
23 ventilation of the repository tunnels.

24 The DOE is actively identifying and evaluating  
25 enhancements to the reference design. These are features

1 that are added to or changed in the design without altering  
2 the fundamental nature of the design itself. We recommend  
3 that the descriptions and approximate cost of enhancements  
4 be included in the VA and that their effects on long-term  
5 repository performance be included in the TSPA VA  
6 sensitivity studies.

7 I am pleased now to turn the presentation over to  
8 my colleague, Dr. Knopman.

9 MS. KNOPMAN: Let me pick up the second element of  
10 the viability assessment, which is the total system  
11 performance assessment, or TSPA. TSPA is the principal, but  
12 not the only method of evaluating the ability of the  
13 proposed repository to contain and isolate waste. It is, of  
14 course, important that we also look at solid conceptual  
15 models, good data, field work, and use the TSPA,  
16 particularly the sensitivity analyses, as a way to gain  
17 insight into the uncertainties of this program.

18 TSPA is essentially a predictive computational  
19 model of repository performance over time. DOE is charged  
20 with carrying out a performance assessment that emphasizes  
21 the probable behavior of the proposed repository.

22 This past year, DOE has devoted significance and  
23 laudable effort to achieving the goal of a credible TSPA.  
24 The emphasis on probable behaviors resulted in a division of  
25 TSPA into two parts, a base case calculation and a series of

1 sensitivity tests.

2 The base case concentrates on probable or expected  
3 performance and the sensitivity studies concentrate on what  
4 if scenarios for alternative parameters and design features  
5 and various disruptive events, such as volcanic activity and  
6 earthquakes.

7 Extensive workshops have increased the interaction  
8 within the program and have given the DOE substantial expert  
9 input from outside the program. These expert elicitations  
10 have brought together field and laboratory scientists,  
11 modelers, performance assessment experts from within the  
12 program on many important topics.

13 Some of these workshops primarily from outside the  
14 Yucca Mountain project have helped to better define the  
15 conceptual and parameter uncertainty of the elements that go  
16 into TSPA.

17 DOE also took an important step in 1997 by forming  
18 an external TSPA peer review panel to delve into important  
19 aspects of the TSPA VA. The Board is very encouraged by the  
20 strong and independent comments being provided by the TSPA  
21 peer review panel.

22 Let me turn to the third element of VA, which is  
23 the plan and cost estimates for license application.

24 The Board is going to focus its review on this  
25 particular element, on the plans for an estimated cost of

1 technical activities supporting a license application. In  
2 particular, the Board believes the data from the new ECRB  
3 program, I still want to call it the east-west crossing, and  
4 other studies, among other planned studies, are vital for  
5 the Secretary of Energy's decision on the suitability of  
6 Yucca Mountain.

7           This decision precedes submittal of a license  
8 application to the NRC. There are many other ongoing  
9 technical activities; for example, long-term corrosion test  
10 program, there is what is called drift scale thermal tests,  
11 and some other additional hydrological tests and wells, and  
12 in the exploratory studies facility, that also must continue  
13 to support licensing.

14           The Board is going to want to insure that those  
15 activities are included in the license application plan and  
16 cost estimates.

17           The fourth and final element of the VA is the  
18 repository cost estimate. Because the Board's purview is  
19 technical, we will confine our review largely to those  
20 aspects of the cost estimate that involve technology  
21 development.

22           For example, the Board would be interested in  
23 techniques, allowances, contingencies used in the cost  
24 estimate to reflect the costs of technology development and  
25 to reflect current technical or engineering uncertainties.

1           Another cost issue that the Board will explore is  
2 how potential enhancements to the repository design that are  
3 not part of the reference design case are handled. The  
4 Board was very pleased to learn that an independent review  
5 of the cost estimate for the mined geologic disposal system  
6 will be performed for the VA by a major U.S. engineering  
7 construction firm.

8           It is important that the DOE clearly define for  
9 the cost estimate reviewer the construction process and the  
10 contracting basis that will be used to construct the  
11 repository.

12           Let me turn now to a very brief discussion about  
13 regulations, standards, and the environmental impact  
14 statement.

15           During 1997, the Board reviewed and commented on  
16 two aspects of the regulatory requirements for a geologic  
17 repository; siting guidelines and DOE's interim performance  
18 measure.

19           With regard to the siting guidelines, in April of  
20 last year, the Board submitted comments on DOE's draft  
21 revisions of its siting guidelines. That's 10 CFR 960. In  
22 the draft revisions, the determination of whether the Yucca  
23 Mountain site is suitable for development a repository would  
24 depend no longer on several individual criteria. Instead,  
25 DOE's draft suggested that a suitability determination would

1 be based solely on whether the repository system's both  
2 natural and engineered barriers can meet a post-closure  
3 risk-based standard that will be specified by EPA.

4 In the draft revisions, DOE proposed using the  
5 TSPA methodology to support this determination. In effect,  
6 the former multiple criteria standard would be integrated  
7 and subsumed into a single performance standard.

8 In the Board's April letter, it indicated that the  
9 proposed revisions were, in fact, a step in the right  
10 direction, in our view, but the letter also expressed some  
11 concern that the revised guidelines might be perceived as  
12 changing the rules in the middle of the game and  
13 strengthening the fears of some that performance assessment  
14 may be manipulated to support any conclusion that's desired.

15 To deal with that concern, the Board offered  
16 several suggestions for strengthening the proposed  
17 revisions. One, preserve the principle of defense-in-depth;  
18 two, require that a repository system complies robustly with  
19 the standard; three, specify the level of confidence that  
20 must be reached before making a site suitability  
21 determination; four, make performance assessments  
22 transparent; and, five, use a public process to decide  
23 whether the Yucca Mountain site is suitable.

24 With regard to DOE's interim performance measure,  
25 the second regulatory issue that the Board commended on, in

1 the absence of environmental standards from EPA, the DOE has  
2 developed its own interim performance measure, and this is  
3 for DOE's own use in guiding its technical program and  
4 communicating with others about the potential performance of  
5 the repository at Yucca Mountain.

6 The interim performance measure will be discarded  
7 if and when EPA sets standards for Yucca Mountain. The DOE  
8 did follow the recommendations and at least take into  
9 account the recommendations of the National Research  
10 Council's '95 report, referred to as the technical basis for  
11 Yucca Mountain standards.

12 The DOE's interim performance measure emphasizes  
13 protection of individuals living within the vicinity of  
14 Yucca Mountain; specifically, the annual dose to an average  
15 individual in a critical group living 20 kilometers from the  
16 repository, not to exceed 25 millirems per year for 10,000  
17 years.

18 Both the form of this performance measure and its  
19 level of safety are similar to many other existing radiation  
20 protection standards. With one exception, from the Board's  
21 point of view, this interim performance measure seems  
22 appropriate for DOE's use. The exception is the inclusion  
23 of children from the definition of the critical group.

24 The Board recommended that the DOE should estimate  
25 the disclosed likely variation in doses for alternative

1 candidate critical groups, characterized by different  
2 locations, ages and lifestyles. In particular, the Board  
3 suggested the potential doses to children should be compared  
4 with doses to adults within each candidate critical group.

5 I'll now turn to the environmental impact  
6 statement. Assuming that the site is determined to be  
7 suitable, the DOE plans for the Secretary of Energy to  
8 recommend to the President in the year 2001 that the  
9 President approve Yucca Mountain as a site for a repository,  
10 and that recommendation must be accompanied by an EIS.

11 Many of you know that much of the work on the EIS  
12 was deferred in 1996, a response to reduced appropriations.  
13 In 1997, DOE resumed work on the EIS in earnest.

14 The DOE's EIS contractor mobilized staff,  
15 familiarized them with the project, as necessary, and began  
16 to assemble and analyze the data.

17 In 1998, the Board will be devoting some of its  
18 time to understanding the organization and content of the  
19 EIS. In particular, the Board believes the selection and  
20 characterization of the no-action alternative is critical to  
21 the technical success of the EIS process. Indeed, the  
22 delineation of each of the alternative actions is critical  
23 to the EIS.

24 The Board strongly endorses development of  
25 alternative repository and waste package designs and

1 believes that the EIS process is an appropriate venue for  
2 exploring these alternatives.

3 Let me next turn to transportation. During 1997,  
4 the Board reviewed the transportation of spent nuclear fuel.  
5 The Board's review concentrated on Federal regulations  
6 governing the transportation of spent fuel, analyses of the  
7 risks of transportation, and transportation practices and  
8 experiences.

9 The Board reached three conclusions, which I will  
10 just quickly highlight for you now. The Board continues to  
11 believe that the risks associated with transporting spent  
12 fuel are low based on current experience. However, if there  
13 is a large increase in the scale and operational complexity,  
14 as might occur when spent fuel is shipped to a repository or  
15 an interim storage facility, a heightened safety program  
16 will be needed to maintain a good safety record.

17 The existing capability to transport spent fuel in  
18 the U.S. is small and much preparatory work needs to be done  
19 before fuel can be transported in large quantities. More  
20 transportation casks with larger capacities are needed.

21 The transportation infrastructure at some sites  
22 will need to be upgraded to allow moving heavy loads and  
23 substantial institutional planning is needed.

24 Finally, the third conclusion of the Board with  
25 regard to transportation is that certain measures, such as

1 the use of dedicated trains and full-scale testing of casks,  
2 may enhance the perceived level of safety. Because the  
3 risks of transporting spent fuel are low based on current  
4 experience, it is unclear whether such measures would be  
5 justified solely for risk reduction, but they may increase  
6 confidence in the safety performance of the transportation  
7 system.

8 MR. COHON: Dr. Parizek will now continue.

9 MR. PARIZEK: Chairman Jackson, it's an honor to  
10 address the Commission. I am on the Board for one year and  
11 I think perhaps the new Commissioners struggle with catching  
12 up to speed on very complicated technical issues, so we  
13 share some common anxiety in this regard.

14 But I've been watching the progress of the Yucca  
15 Mountain project for a number of years and, off the record,  
16 there has been a considerable effort made in the last  
17 several years and the whole program has ramped up, resulting  
18 in some very exciting technical findings.

19 The completion of the exploratory studies facility  
20 being one point. I think many of you may have seen a film  
21 of the breaking out of the tunnel, boring machine, last  
22 April, that would be on the 25th of April. That's about a  
23 five-mile long tunnel and about 26 feet in diameter, and it  
24 took achievement to complete that goal.

25 As anticipated by the Board, the excavation of

1 this tunnel provided a wealth of anticipated and  
2 unanticipated data on the geological and hydrological  
3 character of Yucca Mountain. It was a very valuable  
4 learning opportunity for the Yucca Mountain project in  
5 performing contractor oversight, managing construction, and  
6 understanding the value of seeking independent counsel from  
7 construction industry experts.

8           Some of the lessons learned are listed below, one  
9 being the type of construction contract is important.  
10 Underground construction worldwide uses competitive  
11 processes, normally including fixed-price contracts.  
12 Cost-plus contracts, such as used by DOE for the ESF, have  
13 no known precedent in underground construction and probably  
14 little, if any, incentive for efficient or cost-effective  
15 construction.

16           Secondly, the contractor knows how to manage risks  
17 associated with equipment design and performance. So  
18 design, procurement, and disposal of construction equipment,  
19 including tunnel boring machines, are normally left to the  
20 construction contractor.

21           Specifications for such as the hydraulic spill  
22 mitigation, dust control and safety requirements can be  
23 defined and enforced without telling the contractor how to  
24 accomplish those objectives.

25           Industry expertise is important and accessible.

1 In 1995, they experienced several difficulties in excavating  
2 the ESF. DOE, in conjunction with the contractor,  
3 established a consulting board. This was largely through  
4 roof falls and broken rock conditions which made the startup  
5 of the tunnel difficult.

6 This Board was very effective in achieving  
7 improvements and the DOE is commended for involving outside  
8 expert consultants.

9 Large diameter tunnels are more expensive and  
10 time-consuming to construct than smaller diameter tunnels.  
11 The design for Yucca Mountain repository includes large, a  
12 7.6 meter diameter tunneling, for service tunnels and  
13 exhaust drift. Smaller tunnels would be affected much less  
14 by the highly fractured nature of the rock. You would have  
15 less risk for rock falls and require less support, and it  
16 would be much more constructable than the large proposed  
17 tunnel.

18 So there have been some strong views by the Board  
19 on these issues.

20 The east-west tunnel is something the Board had  
21 recommended the importance of doing some years back. The  
22 Board previously recommended this excavation at an elevation  
23 at the repository level parallel to an emplacement drift,  
24 and DOE decided to place the exploratory tunnel facility  
25 above it and on a diagonal to it, in order to maximize

1 information with different rock units to be penetrated by  
2 the tunnel and also to provide an opportunity for doing  
3 experiments above the experimental tunnel facility that's  
4 already there.

5 The principal focus of this tunnel would be to  
6 obtain data to reduce the uncertainty of the  
7 hydro-geological environmental within the repository. The  
8 DOE has accepted this recommendation in general, but has  
9 expanded the scope, which is known as the enhanced  
10 characterization of repository block program, which consists  
11 of the tunnel and two bore holes to be drilled from the  
12 surface and all excavations, including three alcoves off the  
13 tunnel, will be completed by about January 1, 1999.

14 The next slide would be helpful in showing where  
15 the present ESF is located. You see in the diagram it's  
16 east-west orientation and you see the north ramp, comes to  
17 the point of the little round circle, having gone through  
18 the Ghost Dance Fault, and then that turns southerly and  
19 continues south parallel to the Ghost Dance Fault, before  
20 breaking back out to the mountain on the southern ramp,  
21 which you saw, I guess, the film, Breakout, pictures.

22 Above it, you'll notice the east-west tunnel rises  
23 up above and continues in a southwesterly direction,  
24 penetrating the Solitario Canyon Fault on the west of the  
25 block. Again, there's the importance of knowing what the

1 rock conditions and the hydrologic conditions are like in  
2 that repository environmental, because the original idea of  
3 maybe you would use the block to the east of the Ghost Dance  
4 Fault is not currently in the planning, as we understand it.

5 Notice that the emplacement drifts, the black line  
6 is located well below the east-west tunnel. The purpose  
7 here would be to give DOE a chance to do experiments,  
8 percolation type testing, to perhaps force water flow  
9 between the east-west crossing in the tunnel to understand  
10 better how water moves in the mountain.

11 So what we have then is this block, which, without  
12 this tunnel, you wouldn't have any idea about the faults.  
13 You don't see them at the surface, but if they're there, you  
14 need to know about this and this is one way to learn about  
15 it.

16 The Board supports a decision by DOE to excavate  
17 the east-west tunnel expeditiously, although the  
18 hydrological testing may not start until 1999, observations  
19 and mapping and limited data on chlorine-36, which would  
20 indicate possible flow paths for water moving through the  
21 mountain, and available -- would be available ahead of the  
22 VA.

23 This is important because the chlorine-36 is the  
24 main indication of fast water flow through portions of the  
25 mountain that you're familiar with.

1           The thermal testing program is also in an  
2 important stage right now. One of the primary functions of  
3 the ESF is to provide access to the strait in which the  
4 repository is to be located and to conduct thermal testing,  
5 especially the effects of repository heat on movement of  
6 water within highly fractured and unsaturated rock.

7           The data from the thermal testing will be useful  
8 for validating the various hypotheses and assumptions used  
9 in developing performance models in the current repository  
10 design.

11           Two tests are being conducted in ESF, a  
12 single-heater test and a drift scale test. The  
13 single-heater test has been in a cool-down phase since May  
14 1997 and all testing was to be completed by the end of  
15 January 1998. Post-test analyses within this portion of the  
16 ESF are planned and the information should be available for  
17 incorporation in the viability assessment.

18           And the single-heater test is placed in the block  
19 of rock surrounded by essentially tunnels on several sides,  
20 and, again, it's a limited period and a limited heat source.

21           The drift scale test, on the other hand, is  
22 located in a about a 156-foot long test area and it's  
23 equipped with heaters that simulate the thermal conditions  
24 of a waste package in a repository. On December 3, 1997,  
25 the heaters were turned on and data collection was begun

1 from sensors in the surrounding rock mass. There are  
2 thousands of measurement opportunities that are being taken  
3 and will continue to be taken through the duration of the  
4 experiment.

5 The heating phase is planned to last approximately  
6 four years, with normally four years for cooling afterward.  
7 The DOE is to be really complimented and commended on  
8 implementing this extensive and important thermal testing  
9 facility. It was ahead of schedule and required a  
10 considerable effort.

11 The large block test is an additional thermal test  
12 being conducted on the surface near Yucca Mountain,  
13 unexcavated outcrop of welded tuft. It was designed to  
14 promote formation of reflux or heat pipe zones, as heat is  
15 applied to the bottom of a large block of fractured rock.  
16 The heat pipe is more or less the concept by which water  
17 flow returns back through a boiling zone as a water  
18 condensing somewhere up above in an emplacement drift.

19 Water mobilizes as vapor and then is expected to  
20 be driven out of the pores of the rock and to flow upward,  
21 where it will condense in cooler regions of the rock. The  
22 condensate then will return as reflux to the above-boiling  
23 zone.

24 On February 28, 1997, the heaters were turned on  
25 and the test was nearing completion at the end of 1997.

1           Our major concern would be what happens when  
2 radionuclides might actually reach the water table. In late  
3 1997, the Board visited Yucca Mountain and nearby Amargosa  
4 Valley for field observations about the flow of ground water  
5 between Yucca Mountain and the Amargosa Valley region, how  
6 ground water conditions varied in the past as the climate  
7 varied and how radionuclides -- radioactive material was  
8 released to ground water might in the future enter the human  
9 biosphere through seeps or springs or withdrawal through  
10 wells.

11           Estimates of the concentrations of radioactive  
12 materials entering the environmental south of Yucca Mountain  
13 repository will be highly uncertain.

14           The saturated zone is highly fractured and faulted  
15 and caused ground water flow to be channelized or there's a  
16 chance of having sort of like a fast-path type of flow  
17 rather than kind of a diffuse mechanism of flow. So we  
18 would have this chance of having these more transmissive  
19 zones.

20           Within these zones, ground water movement will be  
21 faster than the average ground water flow rate through the  
22 saturated zone and retardation of radionuclides may be less  
23 than average, mixing of ground water-containing  
24 radionuclides and the radionuclide-free ground waters within  
25 the saturated zone will dilute radionuclide concentrations,

1 but demonstrating the degree to which mixing would occur in  
2 a channelized flow system may prove very difficult.

3 An important and perhaps greater source of  
4 dilution may be mixing at a well head or a spring, where  
5 ground water leaves an aquifer and enters the biosphere.  
6 This depends on the specifics of the well withdrawal.  
7 Dilution by flow and transport in the saturated zone is  
8 difficult to quantify because of its significance in  
9 determining the relevant importance of different factors  
10 affecting dilution and an early definition of well  
11 withdrawal scenarios could provide an important focus for  
12 studies at Yucca Mountain.

13 The fate of radionuclides after the end of the  
14 biosphere and as they enter food chains and potentially  
15 cause radiation doses to humans must be projected. The use  
16 of generic data and models of the transfer of radionuclides  
17 through the food chains may cause large uncertainties in  
18 estimating radiation doses, perhaps as much as three or four  
19 orders of magnitude.

20 Part of this is the specific nature of conditions  
21 at the site. With that climate, it may make the pickup of  
22 radionuclides different than what might appear in the  
23 standard data tables that support this.

24 Thank you.

25 MR. COHON: Thank you, Dr. Parizek. I have one

1 last issue that I would like to cover in our prepared  
2 statement, and that is the use of experts from outside of  
3 the DOE, an important topic, we think, and one that we know  
4 that the NRC has focused on in the past.

5 The DOE is to be commended, as you heard already,  
6 especially from Dr. Knopman, in their stepped-up and  
7 effective use of experts from outside of DOE.

8 They have two very important standing panels that  
9 they have used extensively; the TSPA peer review panel,  
10 which has been very active recently, and the mine geologic  
11 disposal system consulting board, which has been very  
12 effective, first, in the completion of the ESF and, more  
13 recently, in planning for the ECRB.

14 In addition, the DOE has become more active and  
15 very extensively so in the last two or three years in the  
16 use of experts who are not part of one of these existing  
17 panels, but from whom opinions are sought in a formal  
18 process.

19 This seems to have worked very well. We, the  
20 Board, consider this to be an important activity for DOE,  
21 especially in areas where there is great uncertainty, which  
22 is to say much of what they're working on in Yucca Mountain,  
23 and before all of the relevant data can be in hand, which is  
24 also much of what they're working on at Yucca Mountain.

25 Some notable examples of successful application of

1 successful use of outside experts are in estimating seismic  
2 and volcanic hazards, unsaturated zone and saturated zone  
3 flow, and waste package degradation.

4 The Board has pointed out and I want to emphasize  
5 today that there are continuing issues that the DOE must  
6 deal with in the use of these outside experts. In  
7 particular, we remain concerned about those situations where  
8 there are very few experts and those experts sharply  
9 disagree. This is a difficult problem, certainly not unique  
10 to DOE's use of experts or, of course, to Yucca Mountain,  
11 but nevertheless a problem that must be dealt with if their  
12 information is to be used effectively.

13 Let me conclude by saying that, as I said at the  
14 beginning, this has been a very busy and eventful year, both  
15 for the Board and for the program at DOE, and, if anything,  
16 the future seems even more eventful, as we look forward.

17 As we know, the VA will be issued later this year,  
18 a time when the Board will be expected to comment, and that  
19 will be a key milestone as DOE moves to siteability  
20 determination approximately in the year 2001 and all that  
21 comes after that.

22 That concludes our remarks. We look forward to  
23 your questions. Thank you, Chairman.

24 CHAIRMAN JACKSON: Thank you. Let me begin by  
25 asking you a couple of questions and I'm going to wade right

1 in to a couple of quasi-controversial topics.

2 Given what you talked about vis-à-vis the  
3 possibility or likelihood of channelized flow, with possibly  
4 limiting dilution and retardation, possible dilution as the  
5 water is withdrawn, perhaps via well, does the Board have a  
6 view on what that might -- whether that necessitates having  
7 a separate ground water protection standard?

8 MR. COHON: You did say you wanted to get right to  
9 controversial issues.

10 CHAIRMAN JACKSON: Right.

11 MR. COHON: And congratulations, Chairman Jackson,  
12 you did just that. Do either of my colleagues want to take  
13 this one to start?

14 MS. KNOPMAN: Why don't you start?

15 MR. COHON: Now we know it's controversial. They  
16 refused.

17 Indeed, this a very sensitive topic, sensitive in  
18 the sense of having big impact on the estimates for probable  
19 doses. As the Chairman pointed out, there are two key ways  
20 in which dilution may occur. One is in the saturated zone  
21 that is below the water table after the waste migrates to  
22 that point and then when the water is withdrawn. Dr.  
23 Parizek referred to these, as well.

24 On the first point, while we have heard what we  
25 have listened to the experts say, and this was a case where

1 DOE appealed to outside experts and they had superb people,  
2 by the way, on their expert panel. Where the experts felt  
3 there was considerable uncertainty about the effect of  
4 dilution in the saturated zone, that, if anything, they felt  
5 it was more probable that significance dilution would not  
6 occur. Channelization would occur, as you said.

7 That we should expect the plume to stay fairly  
8 much intact rather than spreading out greatly. That's their  
9 expectation.

10 Dilution at a well head offers -- could be very  
11 large. I guess the big difficulty here is whether one can  
12 count on that. It is possible to sink a well and take water  
13 just from one strata and, therefore, get no dilution, no  
14 significance dilution. That may be a low probability event,  
15 but it's possible. I think the key question, of course,  
16 will be, as the Chairman put it, what the standard says.

17 Now, colleagues, do you want to expand or subtract  
18 from what I said?

19 MS. KNOPMAN: No. You did an excellent job. I  
20 would just add that in thinking about these different well  
21 withdrawal scenarios, you could get the substantially  
22 different result if you were, say, looking at a well field  
23 rather than an individual well and you were looking at total  
24 pumping rate from a well field, let's say a water company,  
25 and then the mixing of all those waters prior to delivery to

1 the population.

2 That would produce a different, substantially  
3 different dilution than what would get from looking simply  
4 at single-well withdrawals that either may intercept  
5 multiple layers, in which case you could get substantial  
6 dilution, or a single layer at a direct hit rate into the  
7 center line of a plume.

8 So there is tremendous variation within the well  
9 withdrawal scenarios from the kind of result that you might  
10 -- the kind of dose that you might be delivering to the  
11 population.

12 MR. PARIZEK: I have a feeling that the ground  
13 water is a part of a system and even if you didn't want to  
14 take any credit for the ground water system by saying  
15 nothing can be released to the water table below the site,  
16 you lose some sense of reality.

17 Materials in time do reach the water table. There  
18 can be some forgiveness there. There are faults and there  
19 are fracture zones, but not all of the rock mass is  
20 necessarily that way and a certain amount of the flow paths  
21 from the unsaturated zone reach the rock mass below and  
22 there would be a tie-up or hold-back of some portion of the  
23 water.

24 The question is what percentage of that would be  
25 in the diffuse part of the system and what portion in the

1 fast-path part.

2 So the idea is that there would be some  
3 retardation. There is bound to be some diffusion and matrix  
4 diffusion from the fracture zones and fault zones, and there  
5 could be benefit.

6 There is also alluvium, which is present to the  
7 south of the site, the exact location of where the saturated  
8 zone alluvium versus bedrock occurs. It's not too well  
9 known. It's an area generally of data deficiency. But  
10 alluvium would give us a slowing down of the flow rates,  
11 much higher chance for retardation than might be possible in  
12 the fractured rock. So there's benefits to be received  
13 there.

14 On the other hand, to say that you will base all  
15 of it on dilution to protect the human health, maybe at that  
16 point, if dilution of the well head is your last part of the  
17 calculation perhaps, you hit some credit, but it makes a  
18 difference whether there's one well or groups of wells or a  
19 large well field. That's a future that may be a little bit  
20 hard to characterize.

21 So I say you should give some credit to the ground  
22 water system. More can be learned about the ground water  
23 system and more is underway to be learned about it by some  
24 of the deep drilling that's being planned, is underway at  
25 the Yucca Mountain site.

1           CHAIRMAN JACKSON: Are you looking at or do you  
2 feel that DOE needs to look at, for lack of a better  
3 terminology, whether it makes any sense to talk about  
4 institutionally controlled use in design?

5           MR. COHON: Institutional control of the water, is  
6 that what you're talking about?

7           CHAIRMAN JACKSON: Let me make sure I make myself  
8 clear. Just as you talk about engineered barriers, you  
9 raised -- you said the key question is what the standard  
10 says, but leading up to that, can one count on dilution at  
11 the well head and there is one way one could answer that  
12 within the context of -- or try to answer it probably using  
13 expert opinion or judgment.

14           There is one way one can try to get at that  
15 vis-à-vis coming at some best estimate of what the natural  
16 environmental would allow or suggest and to what extent one  
17 could make some predictive statement down the line.

18           The second part of it that this flows into, but  
19 not unlike the whole issue of engineered barriers is to what  
20 extent can one -- or does it make sense to talk along that  
21 line, design in institutional controls? Because if you're  
22 talking looking down the line, the issue of institutional  
23 controls in terms of organized society is something that you  
24 can't talk about.

25           MR. COHON: Right. Chairman Jackson, I remember

1 vividly appearing at the House hearing on the legislation,  
2 on a panel with you, and a member of the committee asked the  
3 question that was not unlike this, though he was looking in  
4 the future.

5 He was talking about human intrusion into the  
6 repository, which has always been a very difficult issue to  
7 deal with. And what I said then, which I'm not sure if it  
8 came back to haunt me or not, but it still might, was that  
9 based on the study by the other NRC, that we basically  
10 considered those kinds of issues not tractable or not  
11 ponderable, things that were beyond us.

12 Now, I wonder if the issue the Chairman has raised  
13 would fall under that. Can one say with any confidence that  
14 if water is developed a thousand years from now, it will be  
15 managed by a water company managing a whole well field and,  
16 therefore, getting maximum benefit from doing that, if there  
17 is any contamination. I don't know.

18 MS. KNOPMAN: The Board is agnostic at this point  
19 as to whether well withdrawal is the appropriate one to use  
20 in the regulatory context. Our concern is the predictive  
21 capability of the models that might be used as a basis for  
22 making any further predictions about the dilution at the  
23 well head and right now the models, saturated zone modeling  
24 effort is -- also pardon the pun -- in flux and is not at a  
25 point where there really is stability in its predictive

1 capability.

2 So that's where our concern is right now as to how  
3 to improve that capability.

4 CHAIRMAN JACKSON: Because I think you hit it on a  
5 few sentences ago, and that is, you know, what is  
6 appropriate or what do you need to decide what is  
7 appropriate in a regulatory context, because that's kind of  
8 where the rubber meets the road for us.

9 Let me go on and ask controversial question area  
10 number two. I had a question for you which went like this;  
11 to what extent is the DOE program focused on the most  
12 important issues related to the overall performance of the  
13 repository? And, of course, so as to have full disclosure,  
14 you mentioned things like the various thermal tests and,  
15 related to that, hydrologic studies.

16 In fact, I've just happened in the past couple of  
17 months to be out and I've looked at the large block path  
18 heater, the drift heated test and so forth.

19 But the real question becomes -- we, of course,  
20 have this -- and I don't mean for you to give a definitive  
21 answer. I'm more interested in where your thinking is  
22 going.

23 Were you surprised by the article in Science and  
24 what it suggests about the volcanism and to what extent do  
25 you feel DOE is giving attention in that area and has your

1 opinion in that regard changed vis-à-vis the recent Science  
2 Journal article?

3 MR. COHON: Let me say, first of all, as a general  
4 matter, that I believe the program right now is much more  
5 focused and effectively so than it was just two years ago  
6 and much, much more than it was five years ago, as it should  
7 be.

8 I think DOE deserves a lot of credit for having  
9 been able to go from basically a science program to  
10 something really focused on the question, is this site  
11 suitable. I think we need to keep that in mind.

12 As a Board, we have been asking ourselves just  
13 this question, Chairman Jackson; that is, how much more  
14 should the program be focused, recognizing that if the  
15 program sticks to schedule, there's really very little time  
16 left between now and the point where they are likely to  
17 recommend to the President that the site be found suitable,  
18 and then come to you to apply for a license.

19 In light of that, the DOE needs to be very  
20 efficient and use its very limited resources in the most  
21 efficient and effective way possible.

22 We are, within the Board and working with DOE,  
23 trying to develop our own understanding of what that might  
24 be, how much more focused can the program become, and the  
25 key here, of course, is identifying the key uncertainties

1 that will remain after VA and to focus resources on  
2 resolving those uncertainties that can be resolved or can be  
3 reduced. Resolving them is probably too strong a word, but  
4 can be significantly reduced between VA in the time that  
5 suitability is determined.

6 We are not surprised to here about -- we are not  
7 surprised by the Science article. We've been aware of that  
8 research for some time and have been tracking it. We may be  
9 a little more surprised by the press reports of the Science  
10 article, which is, of course, a different matter.

11 CHAIRMAN JACKSON: Come work with us. You get a  
12 lot of press reports.

13 MR. COHON: That's right. Now, I don't have the  
14 exact date, but I believe that there is a meeting coming up  
15 in the next month or so. Does someone know, offhand?

16 MS. KNOPMAN: Seismic hazard assessment.

17 MR. COHON: I'm sorry. But there is a meeting  
18 coming up where this will be looked at more carefully.

19 In particular, understanding the uncertainties  
20 associated with the data itself that's reported on in  
21 Science and then trying to understand what the implications  
22 of that might be for seismicity or other activity.

23 MS. KNOPMAN: Can I just add a little bit to that?

24 CHAIRMAN JACKSON: Please.

25 MS. KNOPMAN: This is an area of the seismic and

1 volcanic hazards where DOE did seek out outside experts and  
2 it's been -- that group has been meeting for quite some time  
3 and, in fact, probably did better at coming to closure than  
4 some of the other groups. So I don't think this was a  
5 surprise to the program.

6 You raised the question about what's important  
7 here and how does -- is the program focusing on what's  
8 important, and the Board, just to give you a flavor of where  
9 the Board's thinking is.

10 When you get right down to it, what we're talking  
11 -- what we're most interested in is what the near-field  
12 environmental is for those waste packages, and that means  
13 understanding the water, water flow in and out, and what's  
14 happening in terms of the conditions in which the canisters  
15 are going to be subjected.

16 I think the program has, because of the use of the  
17 outside experts, there is actually a specific panel, expert  
18 elicitation panel that's been convened specifically on the  
19 near-field environmental and I think the department is  
20 getting to that focus and that's also, I think, one of the  
21 indicators of how TSPA can be used productively to get  
22 through sensitivity analyses, to get to the heart of what's  
23 really driving the system.

24 So I think they're getting there.

25 MR. PARIZEK: I would say the same. DOE has

1 received a lot of recommendations for the need of follow-up  
2 studies to reduce uncertainty in time for, say, an LA and  
3 this list comes from the expert station panels, it comes  
4 from the NRC through the interaction that you have with DOE,  
5 and it also comes from the Board.

6           The key thing is not to let those programs die  
7 just because it looks like a shopping list for more science.  
8 And if you had asked the program ten years ago what was a  
9 good list, it would have been a long list. Today it's a  
10 much more focused list, but it's an urgent list.

11           And to come before a Commission with a license  
12 application, I maintain you have to have good science and  
13 good engineering to justify your recommendations.  
14 Otherwise, you will perhaps deny and there will be delays in  
15 the program and credibility shrinks.

16           I think it's quite urgent to make sure we track  
17 the remaining the studies that must be conducted, make sure  
18 that they are conducted, and funding is provided to see this  
19 through. Congress has cut the program, but you can't cut it  
20 very much more before the science may drop. And this has to  
21 do with material science, the new areas that are being  
22 talked about.

23           There is a short period of record there. Judges  
24 often feel insecure about our record, but we have analogs,  
25 natural analogs to draw from. The materials people maybe

1 lack some of that same sort of thing. So this  
2 experimentation has to be done on the corrosion processes  
3 and better understand that whole thing, because we put a lot  
4 of faith on a robust barrier, the engineered barrier, but we  
5 got to make sure it's going to work.

6 So I think keep the science alive and the  
7 engineering work going right to the LA deadline.

8 CHAIRMAN JACKSON: I'll make a comment in lieu of  
9 a question. I remember when I visited Yucca Mountain two  
10 years ago and then, of course, I've visited again more  
11 recently, there was a concern here on the science and the  
12 issue is how do you keep the focus in the right technical  
13 areas, but integrating them so it's not just a giant,  
14 multi-part research program as opposed to one that has the  
15 appropriate program integration, driving to understanding  
16 the features most important to repository operation and  
17 safety.

18 And so the question -- so I assume that that's  
19 something that the Board keeps a focus on.

20 So let me just ask one last question and then I'm  
21 going to turn it over to my colleagues.

22 I note that the Board has urged DOE to consider  
23 including alternative design concepts into the viability  
24 assessment, and you mentioned that in your remarks.

25 The question is, do you know if the DOE is doing

1 this and what level of detail are you really looking to see  
2 in the viability assessment with respect to this?

3 MR. COHON: We believe they are. Well, we know  
4 they are. They are looking at alternative designs. We do  
5 not believe that they need to be looked at in great detail  
6 or developed in great detail for the VA. In fact, it  
7 probably is not a good idea, given the limited time and  
8 limited resources, and they do need to develop the reference  
9 design, the base case as fully as possible.

10 Our strong recommendation that they consider  
11 alternatives is so that thinking about the limited time that  
12 remains after VA, if we stick to schedule, we fear that the  
13 program might be get locked into a particular design and  
14 find it difficult to think outside of the box of that  
15 particular design.

16 That's why we have been pushing alternatives so  
17 hard.

18 CHAIRMAN JACKSON: All right.

19 MR. COHON: There are also EIS implications  
20 potentially as well.

21 CHAIRMAN JACKSON: That's right. Commissioner  
22 Dicus.

23 COMMISSIONER DICUS: You mentioned the TSPA peer  
24 review panel that DOE formed last year and I think you  
25 mentioned that you were encouraged by the rather strong

1 independent comments that were coming from that panel.

2           Could you characterize those just a little bit  
3 more, particularly more significant comments regarding the  
4 TSPA?

5           MS. KNOPMAN: As you know, the TSPA is a -- takes  
6 results that have been generated from fairly complex  
7 physical models, mathematical models representing physical  
8 processes, and so the TSPA modeling process is but another  
9 level of abstraction from the underlying mathematical  
10 modeling. And there is a lot that can -- there is a lot  
11 going on there, a lot of assumptions embedded in that.

12           The concern of the peer review group has been as  
13 it has been for the Board, is how much -- by the time you  
14 get to TSPA, results have been grounded in reality, with  
15 real data and some kind of field experience to really back  
16 that up.

17           So the peer review panel, the TSPA peer review  
18 panel went into some depth about concerns of lack of data  
19 and justification for using certain model forms in TSPA.

20           I don't know if you want to elaborate on that.

21           MR. PARIZEK: It continues, I think, with Chairman  
22 Jackson's comment about the focus. I think when you run a  
23 TSPA and sees what seems to drive a system, the so-called  
24 sensitivity analysis part of the what-ifs part, you begin  
25 seeing what are the critical portions of the system that

1 need further work, like the climate effects.

2           Clearly, that's a driving variable. So one has to  
3 deal with that. If corrosion is one, you've got to deal  
4 with that. So whatever the outcome of this next go-around  
5 is that's issued this fall, you will have a clearer picture  
6 of where the study needs are.

7           The question is can you fill the gaps in the time  
8 period between then and LA. In terms of like reaching the  
9 ground water modeling, there are vast areas of areas south  
10 of Yucca Mountain with no well control. As a result, it is  
11 somewhat speculative exactly what rocks are -- hydrological  
12 conditions occur there.

13           And then the question is how much credit would you  
14 want to assign to the ground water rule anyhow. Maybe you  
15 can get a lot more credit out of a canister and say go with  
16 the canister part. But all of these pieces have to somehow  
17 fit together and I think when you're running the TSPA, you  
18 begin finding out how much credit you can get for each part  
19 of it as we understand at this point in time.

20           CHAIRMAN JACKSON: So you're thinking of the TSPA  
21 itself as a manager.

22           MR. PARIZEK: Yes, it is. It's a question of  
23 whether the managers now use it that way, which was your  
24 question. The program seems to have gotten more focused in  
25 recent years than it used to be in terms of grabbing onto

1 critical parts of the story, as I see it.

2 Again, maybe I've missed the point, but TSPA is an  
3 education to all of us and you can't tell what the outcome  
4 is going to be until you finally run it and then it has  
5 uncertainties with it. So what we want is to make sure we  
6 can shore up all of the areas where you don't feel  
7 comfortable, make sure the next go-around is going to be as  
8 thorough and complete as it can be.

9 A lot has been learned at Yucca Mountain since the  
10 early days of that program and, again, there is ramping up  
11 at a rapid rate. There is very good information coming in  
12 that we wouldn't have had only a few years ago, part of it  
13 with the tunnels, part of it with experiments that are  
14 coming to maturity.

15 COMMISSIONER DICUS: Let me ask you a process  
16 question, too. Given the fact that the Board has 11 members  
17 and you have somewhat similar and also maybe differing  
18 expertise, but how -- it's sort of a question about how you  
19 arrive at your decisions, but more importantly, how have you  
20 handled divergent opinions and how will those come forward?

21 MR. COHON: Well, it's not a very pretty sight,  
22 Commissioner Dicus.

23 COMMISSIONER DICUS: Like sausage being made.

24 MR. COHON: That's right. I didn't say that, but  
25 you did. We -- the Board works hard to attain consensus on

1 all major issues, all major positions that the Board adopts  
2 and before we communicate that to DOE.

3 We will vote on occasion, vote for our record,  
4 which is to say the public record, but generally we are able  
5 to reach consensus, and that means a lot of compromise and  
6 discussion about wording and positions about things.

7 Our meetings can get long. They are usually not  
8 very contentious. It's quite a remarkable collection of  
9 people. They are very, very good at working together and  
10 seeking that common ground.

11 I think, based on some recent meetings we've had  
12 which could have been very contentious given the issues we  
13 were discussing, that the Board -- the individual members  
14 enjoy interacting with each other very much and realize that  
15 they learn a great deal from that.

16 Let me correct one possible misconception. You  
17 happen to be looking at the three people with some water in  
18 their backgrounds. The other eight members don't. So, in  
19 fact, we're quite diverse in our backgrounds and what we  
20 bring to the Board, and that helps, as well. So we learn a  
21 great deal from each other because they are experts in  
22 something I'm not, and we listen carefully to each other,  
23 learn, and then generally arrive at consensus.

24 So far, so good.

25 MR. PARIZEK: Could I add a remark? And that's

1 the role of the staff. It is a very dedicated, very  
2 competent staff that keeps an awful lot of this history  
3 going for us, because as new members coming in, there is no  
4 way you can get up to speed on all these activities. All  
5 the expert panel meetings, usually three of them for each  
6 panel, many panels, you can't monitor those activities and  
7 keep track of the literature and so on.

8           So the staff brings an awful lot to the table to  
9 help get us into an understanding of the issues. That  
10 doesn't mean that we buy off on that, but at least it sets  
11 it up for us in a way that we're not having to start from  
12 ground zero and trying to invent all of this material  
13 ourselves.

14           With that, it would be almost impossible because  
15 we all have other full-time jobs and there's not enough of  
16 us to get this job done, the Commission knows the problem of  
17 having a limited number of people with a big assignment.

18           MR. COHON: Just to pick up on one thing that Dr.  
19 Parizek just said, because it will help understanding our  
20 process. He made reference to panels. The Board organized  
21 -- organizes itself into five panels, each with five Board  
22 members on it, and these are panels that are devoted to  
23 specific aspects of the repository problems.

24           Those panels generally take on the leadership on  
25 particular issues and do the work outside of our Board

1 meetings and then inform the rest of the Board members when  
2 we come back together.

3 CHAIRMAN JACKSON: Commissioner Diaz.

4 COMMISSIONER DIAZ: I'd like to say that I have  
5 maintained a very open mind on the issues of Yucca Mountain  
6 by staying ignorant about it and for having a very wide  
7 gradient between ignorance and expertise when we get to  
8 doing stuff.

9 But I was listening to you and was interested in  
10 the drift between science and application and, of course,  
11 science never ends and sometimes we like to keep it going.  
12 But scientific applications have to end and, in this case,  
13 there are some particular date lines and deadlines that have  
14 to apply and then closure to the VA is important and closure  
15 to the LA is important.

16 Thinking on the terms that scientific  
17 applications, engineering and technology and they have to be  
18 closed, do you see any show-stoppers for actually preventing  
19 this repository to becoming reality?

20 MR. COHON: No. I don't believe the Board has  
21 seen any show-stoppers.

22 COMMISSIONER DIAZ: All right. Going back now and  
23 retreating to the fact that I am more of an engineer than  
24 anything else, going back to the engineered barriers, I was  
25 particularly interested in the Board interest in the

1 engineered barriers.

2           There are essentially three issues; small waste  
3 packages, waste packages with two corrosion-resistant, and  
4 ventilation of the repository tunnel. I was having a  
5 problem fitting these things together.

6           When you actually make smaller packages, you  
7 increase the surface significantly, which gives you an  
8 additional potential corrosion problem, and, of course, it  
9 increases cost.

10           It might be better and easier to handle, but it's  
11 certainly an issue. I don't see how it combines by putting  
12 two corrosion-resistant materials in the package because if  
13 you tried to make them smaller, then that becomes more of a  
14 problem. You are actually increasing the actual cost of it.

15           Of course, I guess ventilation of the tunnel is  
16 because you're trying to get humidity out of it?

17           MR. COHON: Exactly right.

18           COMMISSIONER DIAZ: But that also increases some  
19 of the other issues that are -- and I'm very ignorant about  
20 this, but you know we always worried when things have higher  
21 temperature and places with higher temperatures tend to  
22 carry materials away to the lower temperatures.

23           I was wondering whether isolation was part of the  
24 design. So I was having a little problem in looking at the  
25 three of them interacting together, especially looking at

1 closure, resources, and the conditions that were to be  
2 specified.

3 MR. COHON: You should come and spend some time  
4 with the Board. We would enjoy it very much. This is  
5 exactly the kind of thing we hope that DOE will take on.

6 COMMISSIONER DIAZ: I see.

7 MR. COHON: And the key is to view the system as a  
8 system. Now, in this case, these three alternatives that we  
9 identified that you picked up on are distinct from each  
10 other. We're not saying smaller packages and two  
11 corrosion-resistant and ventilation. These are just three  
12 separate, but if you did them all, obviously, interacting,  
13 things one might try.

14 Your analysis of each is very good. But let me  
15 put out one thing that might help you because you're new to  
16 Yucca Mountain and we're happy for you being new to Yucca  
17 Mountain.

18 The whole idea, water is the big issue, as you  
19 heard and as you know. Water is the big issue because of  
20 the impact on the waste packages. So the argument for  
21 ventilation is to keep the tunnels and emplacement drifts as  
22 dry as possible for as long as possible, so as to the reduce  
23 the probability of corrosion. That's the whole argument.

24 So it's the life of the package which is driving  
25 this and that's related to water.

1           COMMISSIONER DIAZ: But I have a problem, and I'm  
2 not a water expert, but every time you remove water, you're  
3 actually increasing some process in looking at pressure and  
4 now you're decreasing the pressure, so you're attracting  
5 more water, if the water is getting there.

6           Sometimes what we'd want to do is we'd want to  
7 keep the concentration high. I don't know --

8           MR. COHON: This is the key point that I want to  
9 make. There is an assumption -- not an assumption. There  
10 is -- the way we understand the problem, and that's the big  
11 we, not just the Board, is that the key thing is keeping  
12 those packages intact as long as possible.

13           So the issue is not -- during the first part of  
14 the life of this repository, the issue is not so much  
15 migration of waste away from the tunnels, but rather keeping  
16 those packages intact because if they're intact, you don't  
17 have anything to worry about.

18           So that's the idea. That's what drives it all.  
19 So we're not so worried early on about gradients that are  
20 created because we're assuming that the packages will be  
21 intact and, therefore, nothing is going to be moving -- no  
22 waste will be moving out of the drifts anyhow.

23           COMMISSIONER DIAZ: Water will be moving in.  
24 That's why we got three water experts today.

25           MR. COHON: That's the whole purpose of these

1 thermal tests. Do you want to say something about that?

2 MR. PARIZEK: The whole idea of of a hot waste  
3 package if you go with a hot repository is it boils the  
4 water out and does so for a prolonged period of time. Part  
5 of the problem is where does the water go you boil out.  
6 It's going to condense somewhere and will want to come back  
7 to haunt you, perhaps right back in some of the emplacement  
8 drifts.

9 So as an example, getting on with the engineering  
10 decision, if you can't decide and the experiments can't be  
11 run long enough to know what happens to this refluxed water,  
12 the choice might be to consider an alternative design, as  
13 suggested by the Board, have a cold repository, in which  
14 case you don't have to deal with this reflecting issue.

15 Maybe you won't solve that problem, but,  
16 nevertheless, right now, if you go into Yucca Mountain, you  
17 never did see a drop of water falling in one you any place.  
18 That doesn't mean it might not be doing that, because you  
19 have the chlorine-36 data showing that somewhere in the last  
20 50 years water got to those depths, but the fact that it's  
21 ventilated means that it keeps it dry.

22 Under the present environment, you could sit in  
23 there and not rust yourself, I suppose, for some number of  
24 years. We haven't had as much time as possible into the  
25 future, when the canister hasn't yet been asked to do

1 anything. It's sitting there waiting for the first arrival  
2 of water, sometime in the distant future.

3 And the moisture would be driven out because of  
4 the heat source that the warmer packages or the hot packages  
5 bring into the mountain.

6 So that was part of the idea of the ventilation  
7 concept. Again, if it doesn't calculate out to be suitable,  
8 you might drop it from the thinking. But right now it would  
9 buy time for canisters, and that's part of the game -- get  
10 the longest life you can out of your waste package before it  
11 has to finally resist a corrosion problem.

12 CHAIRMAN JACKSON: Thank you. Commissioner  
13 McGaffigan.

14 COMMISSIONER MCGAFFIGAN: I'm going to go back to  
15 the Chairman's first line of questioning just for a little  
16 bit. On page 7 of your statement, there was a -- you talked  
17 about them being on the right track with their siting  
18 guidelines and meeting a post-closure risk-based standard,  
19 but then you put some provisos in and one was that you  
20 require the repository system complies robustly with the  
21 standard.

22 Can you define the adverb "robustly?"

23 MS. KNOPMAN: We're working on that.

24 COMMISSIONER MCGAFFIGAN: I mean, I can turn a  
25 25-millirem standard into a .25 millirem standard as

1 robustly, that means a factor of a hundred, or does robustly  
2 mean a factor of 20 percent. In order of magnitude, do you  
3 know what robustly means?

4 MR. COHON: No. We have not quantified it and I  
5 don't know that it's quantifiable until the standard is  
6 quantified and we have an understanding, in a quantitative  
7 sense, of the uncertainties surrounding it.

8 COMMISSIONER McGAFFIGAN: That's the great --  
9 let's stay on that thought. At the moment, they're working,  
10 as you say later on that page, on a 25 millirem all pathways  
11 standard, which is to an average member of a critical group,  
12 and I think ICRP recently suggested 30, but 30 and 25 are  
13 essentially equivalent, especially if we're dealing with  
14 adverbs like robustly.

15 But if you hypothesize -- I don't know how much  
16 the group is familiar with WIPP and whether you've looked at  
17 the WIPP situation, but at WIPP, the EPA has a standard that  
18 includes a ground water MCL standard and it's been salt and  
19 it's been stable for 250 million years and it's probably  
20 going to be stable for 250 million more. So WIPP will pass  
21 whatever standard is imposed, I suspect.

22 But have you done any thinking about an MCL  
23 standard which, using the current MCLs, which are not  
24 risk-based and which go as low as .06 millirem for  
25 strontium-90, et cetera, have you looked at whether Yucca

1 Mountain could possibly pass robustly a standard that  
2 included ground water MCLs?

3 MR. COHON: No. We talk about this all the time,  
4 but it's -- I'm not sure -- well, I better be careful about  
5 going too far with this. What I'm about to say is one  
6 person's view. I am not speaking for the Board here, but  
7 1/11th of the Board.

8 I think it's really too soon to say whether Yucca  
9 Mountain could meet a ground water standard robustly, even  
10 without a definition of the word robust, and I say that  
11 because we're still trying to understand what the  
12 uncertainties are. I think we now know what the key  
13 uncertainties are; that is, where they will come from.

14 But I don't think we know yet -- I don't know yet,  
15 maybe DOE knows now, how big those are.

16 COMMISSIONER McGAFFIGAN: That's my next question.  
17 Later, on page 12, you say those uncertainties could be  
18 three to four orders of magnitude.

19 MR. COHON: Yes.

20 COMMISSIONER McGAFFIGAN: So if I'm now dealing  
21 with something -- and let's say we're going to be robustly  
22 trying to meet a standard and conservative with  
23 defense-in-depth is another principle. And I add all that  
24 up, I may now have a .001 millirem standard for ground  
25 water.

1 De facto, can Yucca Mountain -- can a non-salt  
2 formation meet that sort of standard?

3 MR. COHON: Time will tell. Do I think salt is  
4 more robust? Yes. Do I think WIPP is more robust? Yes.  
5 But that's with still not mature knowledge about Yucca  
6 Mountain. We still have a way to go. I don't think we'll  
7 know at VA, again, one person's opinion.

8 COMMISSIONER MCGAFFIGAN: Could DOE even do the  
9 calculations required at this point, given that they've been  
10 focused on the 25 millirem all pathways standard in time for  
11 VA, if EPA were to propound a standard not dissimilar from  
12 WIPP's standard?

13 MR. COHON: Could DOE do the calculations?

14 COMMISSIONER MCGAFFIGAN: Could they do the  
15 calculations?

16 MR. COHON: Sure.

17 COMMISSIONER MCGAFFIGAN: With dealing with all  
18 these uncertainties?

19 MR. COHON: Yes. TSPA could do that now.

20 MS. KNOPMAN: You need to show them uncertainty.

21 MR. COHON: Exactly right. The key thing would  
22 be what the uncertainty related with that, what that  
23 demonstration would be. That's where we come back to  
24 robustly. That's why we used the word. We know it's vague,  
25 but we think it captures the key point here.

1 I think the Board feels confident that you could  
2 show the repository to meet a standard of the sort that we  
3 expect will come out, but the key question will be the  
4 uncertainty surrounding that, the uncertainty surrounding  
5 the probability with which the standard will be met. If I  
6 said that right.

7 MR. PARIZEK: Could I have a clarification of  
8 whether you're saying at the repository, below the  
9 footprint?

10 COMMISSIONER MCGAFFIGAN: I'll take 20 kilometers.  
11 At the repository, at the footprint, I would assume it's  
12 absolutely hopeless.

13 MR. PARIZEK: I didn't know where your fence,  
14 because certainly WIPP is not a good example for us to be  
15 emulating. You've got the Bell Canyon, which has got a  
16 brine that nobody wants to drink and it's got two dolomites,  
17 which have salty water right above the repository. Nobody  
18 really almost wants to drink. Some people say they have  
19 used that water. So that's a little bit different; the  
20 water could be there, but nobody drinking it.

21 Your question is whether you could get anything to  
22 those aquifers, even if you could.

23 MR. COHON: It will depend very much on what  
24 happens in the saturated zone and what assumptions are made  
25 about dilution in pumping, as Chairman Jackson was

1 suggesting.

2 MS. KNOPMAN: If I can just put my two cents in  
3 here. Where the Board has put its effort is in wrestling  
4 with the question of technical defensibility, so that when  
5 DOE comes forward with an estimate of whether or not it can  
6 meet a proposed standard, has it done so with a set of  
7 assumptions and data and a scientific community consensus  
8 behind it, that it is a credible assessment, even with  
9 uncertainties attached, but, nonetheless, credible.

10 So this is the tough part of figuring out whether  
11 these many models that have been developed do have some  
12 bearing on reality. Sure, they can show something. It's a  
13 question of whether they're showing what we think is  
14 actually going to happen there, and that's where the Board  
15 wants comfort is in understanding that those modeling  
16 representations are a good -- are our best shot at that  
17 representation of the system.

18 CHAIRMAN JACKSON: So perhaps in this context you  
19 would replace robustly with credibly.

20 MS. KNOPMAN: Yes, until we figure out what robust  
21 means.

22 CHAIRMAN JACKSON: Right.

23 MR. COHON: I'm very glad that Dr. Knopman said  
24 what she did. Let me just paraphrase it or expand upon it a  
25 little bit. And that is it is not up to the Board to decide

1 or even comment on what level of uncertainty is acceptable  
2 or not, but rather to comment on the methods and the data  
3 used to arrive at those estimates of uncertainty.

4 Thanks for pointing that out.

5 COMMISSIONER MCGAFFIGAN: Let me just ask. Have  
6 you all taken a position with regard to what a reasonable  
7 standard is?

8 MR. COHON: No.

9 COMMISSIONER MCGAFFIGAN: You have not.

10 MR. COHON: No.

11 CHAIRMAN JACKSON: Commissioner Diaz.

12 COMMISSIONER DIAZ: Just a quick thing on the same  
13 point, I believe. What happens if the uncertainty with any  
14 one of the methods is as large as, say, the basic quantity  
15 that you're trying to measure, what do you do?

16 MS. KNOPMAN: That's a social decision.

17 CHAIRMAN JACKSON: And actually that comes more to  
18 the Commission.

19 MR. COHON: Exactly right.

20 COMMISSIONER DIAZ: So you are going to be trying  
21 to separate this thing so we can actually see what it is.  
22 Thank you.

23 CHAIRMAN JACKSON: Because, in fact, that was what  
24 my basic point was going to be, that in the end, the  
25 definition of robustly and credibly, et cetera, actually is

1 a policy, a policy decision, and it's one that's going to  
2 end up coming to the Commission.

3 Well, thank you very much, Dr. Cohon, Dr. Knopman  
4 and Dr. Parizek. This was an excellent session and you've  
5 raised many of the same issues that the NRC itself has been  
6 concerned with, obviously, vis-à-vis the high level  
7 radioactive waste program.

8 If you'd like to make any comment on our own focus  
9 on the key technical issues, I'm happy to hear it, but I'm  
10 not asking you those questions.

11 I think hearing from you on a more regular basis  
12 as we can move through this pre-licensing phase,  
13 particularly with the viability assessment, et cetera,  
14 coming through.

15 Given that, the Commission truly appreciates your  
16 taking the time to come and present and talk with us today.  
17 There have been a number of key developments in that program  
18 that have occurred over the last few years and we look  
19 forward to continuing to hear from you.

20 Unless there are any further comments, we are  
21 adjourned.

22 [Whereupon, at 3:25 p.m., the public meeting was  
23 concluded.]

24

25

CERTIFICATE

This is to certify that the attached description of a meeting of the U.S. Nuclear Regulatory Commission entitled:

TITLE OF MEETING: BRIEFING BY NUCLEAR WASTE TECHNICAL  
REVIEW BOARD (NWTRB)  
PUBLIC MEETING

PLACE OF MEETING: Rockville, Maryland

DATE OF MEETING: Monday, March 30, 1998

was held as herein appears, is a true and accurate record of the meeting, and that this is the original transcript thereof taken stenographically by me, thereafter reduced to typewriting by me or under the direction of the court reporting company

Transcriber: Natalie Benner

Reporter: Mike Paulus

**The Department of Energy's  
Civilian Radioactive Waste Management Program:  
An Independent Perspective**

**Dr. Jared L. Cohon, Chairman**

**Dr. Debra S. Knopman, Member**

**Dr. Richard R. Parizek, Member**

**U.S. Nuclear Waste Technical Review Board**

**presentation to the**

**U. S. Nuclear Regulatory Commission**

*March 30, 1998  
Rockville, Maryland*

## Introduction

Chairman Jackson, Commissioners, ladies, and gentlemen, good afternoon. It is a pleasure to be here today. My name is Jared Cohon, and I am Chairman 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 president of Carnegie Mellon University and my area of technical expertise is environmental and water resource systems analysis. Accompanying me are two other Board members who will make part of our presentation today. Dr. Debra Knopman is director of the Center for Innovation and the Environment of the Progressive Foundation in Washington, D.C. Her expertise is in hydrology, environmental and natural resources policy, systems analysis, and public administration. Dr. Richard Parizek is a professor of geology and geoenvironmental engineering at The Pennsylvania State University. His expertise is in hydrogeology and environmental geology.

Since we have not met with some of you before, 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 is authorized to have eleven members who are nominated by the National Academy of Sciences and appointed by the President. I have served as a member since 1995 and became the Board's third chairman last year. Drs. Knopman and Parizek were two of eight new members appointed to the Board last year. With this many new members joining the Board at once, we have had a very busy year.

Today, in our prepared remarks, we would like to emphasize our views on the key developments of 1997. We will also briefly discuss our views of the upcoming viability assessment, which we expect to be the focus of much of the Board's activities throughout 1998. Our presentation draws heavily on the Board's 1997 Summary Report which we hoped would have been delivered to you before now. Unfortunately, final editing and printing of the report have taken more time than expected, but you should be receiving the report within the next few days. At the conclusion of our presentation, we look forward to a collegial discussion of the type we have greatly enjoyed during the Board's previous presentations to the Commission.

### Nuclear Waste Technical Review Board

Created by Congress in 1987 to evaluate the technical and scientific aspects of the DOE's civilian spent fuel and high-level radioactive waste management program including site characterization, waste packaging, and transportation.

### Overview of Presentation

- Progress in the Viability Assessment
- Regulations, Standards, and the EIS
- Transportation
- Technical and Scientific Developments

## Progress in the Viability Assessment

As required by the 1997 Energy and Water Development Appropriations Act, the Secretary of Energy is to provide to the President and Congress a viability assessment (VA) of the Yucca Mountain site no later than September 30, 1998. The VA is to include the following elements:

Components of the Viability Assessment
<ul style="list-style-type: none"><li>• Repository and waste package design</li><li>• Total system performance assessment</li><li>• Licensing plan and cost</li><li>• Construction and operating cost estimate</li></ul>

1. The preliminary design concept for the critical elements for the repository and waste package. (The DOE calls this design the "reference design.")
2. A total system performance assessment based on the design concept and the scientific data and analysis available by September 30, 1998. It is to describe the probable behavior of the repository in the Yucca Mountain geological setting in relation to the overall system performance standards. (This component is referred to as the TSPA-VA.)
3. A plan and a cost estimate for the remaining work required to complete a license application.
4. An estimate of the cost of constructing and operating the repository in accordance with the design concept.

The Board intends to conduct a timely review of the parts of the VA that fall within the Board's purview as soon as the VA becomes available. Because the Board is a technical body whose members represent scientific and engineering disciplines, our review will concentrate on technical and scientific aspects of the VA. Essentially, this means that our review will focus primarily on the design and performance assessment components.

Much of the Board's activity during 1997 involved preparation to review the VA. Board meetings during the year focused on performance assessment, hydrology, repository and waste package design, and repository operations. In 1998, we will continue our preparation, and we look forward to reviewing the VA later this year. Now, let me summarize for you the Board's current views on the four components of the VA.

### **Design**

The Board believes that the design area of the Yucca Mountain project had several major accomplishments in 1997. They include refinement of the designs for the repository surface and underground facilities and for the waste package; further integration of spent fuel owned by the U.S. Department of Energy (DOE) into disposal plans; continuing studies of criticality-control issues; and improved integration of engineering and performance assessment. There also were a few shortcomings in the design area in 1997. There are continuing needs to adopt a more robust engineered-barrier system and to thoroughly explore different integrated repository and waste package designs that may offer the promise of better performance, lower cost, reduced uncertainty, or simpler operations.

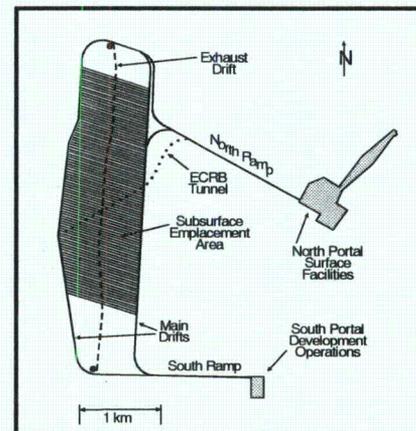
Design
<ul style="list-style-type: none"><li>• Several accomplishments in 1997<ul style="list-style-type: none"><li>- refinements of designs</li><li>- integration of DOE-owned spent fuel</li><li>- studies of criticality-control issues</li><li>- integration of engineering and performance assessment</li></ul></li><li>• Shortcomings<ul style="list-style-type: none"><li>- need more robust engineered-barrier system</li><li>- need to evaluate alternative designs</li></ul></li></ul>

## Repository Surface Facilities

The principal repository surface facilities would be located on an 80-acre site at the repository's north portal and would consist of more than 15 structures and a small railyard. These facilities would receive waste and package it for disposal. Except for the final closure welds and inspections of the waste packages, the Board considers all of the technology of the repository surface facilities to be commercially demonstrated and available. However, the Board does have some remaining concerns about the design basis, including: (1) questions about the assumed peak emplacement rate, which may be unrealistically high; (2) the possibility of transferring some waste packaging operations to nuclear power plant sites, with potential cost savings; and (3) the potential benefits (e.g., safety, standardization) of using multipurpose canisters as part of the overall waste management system. These concerns are discussed in more detail in the Board's 1997 Summary Report.

## Repository Underground Facilities

This slide shows a plan view of the conceptual repository layout. All underground drifts would have circular cross sections. The diameters of the ramps from the surface to the repository, the main drifts around the periphery of the repository, and the exhaust drift (which would be located approximately 10 m underneath the repository) would be 7.6 m, and the diameters of the emplacement drifts would be 5.5 m. The ramps and most of the east main drift exist now as the recently completed exploratory studies facility (ESF). The balance of the main drifts and the exhaust drift would be constructed next, followed by emplacement drifts, starting from the north.



Waste would be emplaced in the drifts, one at a time, starting with the northernmost emplacement drift, and moving to the next drift south after filling a drift. After an emplacement drift is filled, it would be closed off with doors at each end (i.e., where the drift intersects the main drifts on the east and west sides of the repository), limiting ventilation to insignificant amounts. Human entry into a drift would be prohibited after the first waste package has been emplaced in that drift due to high temperatures and high levels of radiation. Therefore, all operation, maintenance, inspection, testing, etc., in drifts containing waste would be done remotely.

The Board recommends in its 1997 Summary Report that the DOE should develop *alternative repository designs* as well as *enhancements* to the reference design. Although it is neither necessary nor appropriate that the alternatives be developed as fully as the reference design at the time the VA is delivered, we believe that including alternative design concepts in the VA could enhance the VA's value and credibility significantly. Thus, we urge the DOE to consider including alternative design concepts in the VA.

## *Engineered Barrier System (Waste Package)*

The reference waste package design is a double-shelled cylinder nearly 2 m in outside diameter by 5 m long with a 2-cm-thick inner shell of corrosion-resistant alloy C-22 and a 10-cm-thick outer shell of carbon steel, a corrosion-allowance material. The waste package will be emplaced on its side on pedestals in the emplacement drift.

Data obtained from the ESF within the last two years clearly show that the repository will be wetter than thought as recently as three years ago. This discovery has triggered examination of enhancements to the existing design. Examples of such enhancements are drip shields and backfill. The Board is particularly interested in seeing studies of additional design options that include: (1) smaller, shielded waste packages, (2) a waste package design using two corrosion-resistant materials (CRM) rather than one CRM and one corrosion-allowance material, and (3) ventilation of the repository tunnels.

The DOE is actively identifying and evaluating enhancements to the reference design. (Enhancements are features that are added to or changed in a design without altering the fundamental nature of the design itself.) We recommend that the descriptions and approximate costs of enhancements be included in the VA and that their effects on long-term repository performance be included in TSPA-VA sensitivity studies.

### **Total System Performance Assessment (TSPA)**

TSPA is the principal method of evaluating the ability of the proposed repository (engineered and natural components acting together) to contain and isolate waste. It is essentially a predictive-computational model of repository performance over time. The DOE is charged with carrying out a performance assessment that emphasizes the *probable behavior* of the proposed repository.

The DOE has devoted significant and laudable effort to achieving the goal of developing a credible TSPA. The emphasis on probable behavior has resulted in a division of the TSPA-VA into a base-case calculation and a series of sensitivity tests. The base case concentrates on probable, or expected, performance, and the sensitivity studies concentrate on "What if?" scenarios for alternative input parameters and design features and disruptive events, such as volcanic activity and earthquakes.

Extensive workshops have increased interaction within the program and have given the DOE substantial expert input from outside the program. The workshops brought together field and laboratory scientists, conceptual modelers, and performance-assessment analysts from within the program on many important topics. Some of the workshops involved eliciting expert judgment, primarily from outside the Yucca Mountain project, to better define the conceptual and parameter uncertainty of the important elements that go into the TSPA. The DOE also formed in 1997 an external TSPA Peer Review Panel to delve into the important concepts and details of the TSPA-VA. The Board is encouraged by the strong

#### Performance Assessment

- DOE is progressing toward a credible TSPA
- TSPA-VA divided into base case calculation and sensitivity studies
- Workshops increased interactions within the program and brought in outside views

and independent comments being provided by the TSPA peer review panel.

### **Plan and Cost Estimate for License Application**

The plan and cost estimate for a license application is the third element of the VA. The Board will focus its review on the plans for and estimated costs of technical activities supporting a license application. In particular, the Board believes that data from the new enhanced characterization of the repository block (ECRB) program are vital for the Secretary of Energy's decision on the suitability of Yucca Mountain. This decision precedes submittal of a license application to the U.S. Nuclear Regulatory Commission (NRC). Many other ongoing technical activities (e.g., the long-term corrosion test program, the drift-scale thermal tests, and hydrological tests in wells and in the ESF) also must continue to support licensing, and the Board wants to ensure that these activities are included in license application plans and cost estimates.

#### Licensing Plan and Cost Estimate

- Board will focus its review on technical activities supporting licensing
- Data from enhanced characterization of repository block needed for licensing
- Other technical activities also needed
  - corrosion tests
  - thermal tests
  - hydrologic studies

### **Repository Cost Estimate**

This is the fourth (and final) element of the VA. Because the Board's purview is technical, we will confine our review largely to those aspects of the cost estimate that involve technology development. For example, the Board is particularly interested in techniques, allowances, and contingencies used in the cost estimate to reflect the costs of technology development (e.g., manufacture of prototype waste packages, development and testing of robotic or remote handling systems for remote emplacement and monitoring) and to reflect current technical or engineering uncertainties. Another cost issue that the Board will explore is how potential enhancements to the repository design that are not part of the reference design case are handled. The Board was pleased to learn that an independent review of the cost estimate for the mined geologic disposal system will be performed for the VA by a major U.S. engineering-construction firm. It is important that the DOE clearly define for the cost-estimate reviewer the construction process and the contracting basis (e.g., fixed price or cost-plus) that will be used to construct the repository.

#### Repository Cost Estimate

- The Board is interested in:
  - costs of technology development
  - costs of engineered enhancements to repository reference design
- Independent cost estimate for VA is good
- DOE needs to define the contracting basis (fixed price or cost-plus) to support cost estimates

## Regulations, Standards, and the EIS

During 1997, the Board reviewed and commented on two aspects of the regulatory requirements for a geologic repository.

### ***Siting Guidelines***

On April 15, 1997, the Board submitted comments on the DOE's draft revisions of its repository siting guidelines, 10 CFR 960. In the draft revisions, the determination of whether the Yucca Mountain site is suitable for developing a repository would depend no longer on several individual criteria. Instead, a suitability determination would be based solely on whether the repository system (natural and engineered barriers) can meet a postclosure risk-based standard that will be specified by the Environmental Protection Agency (EPA). In the draft revisions, the DOE proposed using the TSPA methodology to support this determination. In effect, the former, multiple-criteria standard would be integrated and subsumed into a single performance standard.

Regulations and Standards	
• Siting guidelines	
– the Board generally supports the DOE's proposed amendments	
– Board comments suggested ways to strengthen the proposed revisions	
• DOE's interim performance measure	
– similar to conventional radiation protection standards	
– need to estimate and disclose children's doses	

The Board's April 15, 1997, letter indicated that the proposed revisions represent a step in the right direction. It expressed concern, however, that the revised guidelines might be perceived as "changing the rules in the middle of the game," strengthening the fears of some that performance assessment may be manipulated to support any conclusion desired. The Board offered several suggestions for strengthening the proposed revisions: (1) preserve the principle of defense-in-depth, (2) require that a repository system complies robustly with a standard, (3) specify the level of confidence that must be reached before making a site-suitability determination, (4) make performance assessments transparent, and (5) use a public process to decide whether the Yucca Mountain site is suitable.

### ***The DOE's Interim Performance Measure***

In the absence of environmental standards from the EPA, the DOE has developed an interim performance measure. The interim performance measure is for the DOE's own use in guiding its technical program and communicating with others about the potential performance of a repository at Yucca Mountain. The interim performance measure will be discarded if and when the EPA sets standards for a repository at Yucca Mountain. In developing the interim performance measure, the DOE took into account the 1995 report of the National Research Council's Committee on Technical Bases for Yucca Mountain Standards.

The DOE's interim performance measure emphasizes protection of individuals living in the vicinity of a Yucca Mountain repository. Specifically, the annual dose to an average individual in a critical group living 20 kilometers from the repository is not to exceed 25 millirems per year for 10,000 years. Both the form of this performance measure and its level of safety are similar to many existing radiation protection standards. With one exception, this interim performance measure seems appropriate for the DOE's use. The exception is the exclusion of children from the definition of the critical group. The Board recommended that 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 critical group.

### ***Environmental Impact Statement***

Assuming that the site is determined to be suitable, the DOE plans for the Secretary of Energy to recommend to the President in 2001 that the President approve Yucca Mountain as a site for a repository. By law, the Secretary's recommendation must be accompanied by an EIS.

Much of the work on the EIS was deferred in 1996 in response to reduced appropriations for fiscal year 1996. In 1997, the DOE resumed work on the EIS in earnest. The DOE's EIS contractor, selected in 1996, mobilized staff, familiarized them with the project as necessary, and began to assemble and analyze data for the EIS. In 1998, the Board will be devoting some of its time to understanding the organization and content of the EIS. In particular, the Board believes that the selection and characterization of the "no action" alternative is critical to the technical success of the EIS process. The Board strongly endorses development of alternative repository and waste package designs and believes that the EIS process is an appropriate venue for exploring these alternatives.

#### Environmental Impact Statement

- Any recommendation to develop a repository at Yucca Mountain must be accompanied by an EIS.
- Reduced funding deferred EIS work in 1996, but work was resumed in 1997.
- NWTRB will begin reviewing EIS-related work in 1998, with particular emphasis on selection and development of alternatives.

### **Transportation**

During 1997, the Board reviewed the transportation of spent nuclear fuel within the United States. The Board's review concentrated on federal regulations governing the transportation of spent fuel, analyses of the risks of transportation, and transportation practices and experiences. The Board reached three conclusions.

- The Board continues to believe that the risks associated with transporting spent fuel are low. However, if there is a large increase in the scale and operational complexity, as might occur when spent fuel is shipped to a repository or an interim storage facility, a heightened safety program will be needed to maintain a good safety record.
- The existing capability to transport spent fuel in the U.S. is small, and much preparatory work needs to be done before fuel can be transported in large quantities. More transportation casks, with larger capacities, are needed; the transportation infrastructure at some sites needs to be upgraded to allow moving heavy loads; and substantial institutional planning is needed.
- Certain measures, such as use of dedicated trains and full-scale testing of casks, may enhance the perceived level of safety. Because the risks of transporting spent fuel are low, it is unclear whether such measures would be justified solely for risk reduction, but they may increase confidence in the safety performance of the transportation system.

#### Transportation

- The risks of transporting spent fuel are low
- Existing capability to transport spent fuel is small and much preparatory work needs to be done to move large quantities.
- Certain measures, such as dedicated trains and full-scale testing of casks, may enhance the perceived level of safety.

## Technical and Scientific Developments

### *Completion of the Exploratory Studies Facility*

The excavation of the exploratory studies facility (ESF) was officially completed on April 25, 1997, providing a 7,877-m-long (25,800 ft) tunnel at Yucca Mountain. As anticipated by the Board, the excavation of this tunnel provided a wealth of anticipated and unanticipated data on the geologic and hydrogeologic character of Yucca Mountain and was a very valuable learning opportunity for the Yucca Mountain project in performing contractor oversight, managing construction, and understanding the value of seeking independent counsel from construction industry experts. The following are some of the lessons that can be learned from the construction of the ESF.

Technical and Scientific Developments
Completion of Exploratory Studies Facility
<ul style="list-style-type: none"><li>• Provided a wealth of data</li><li>• Lessons learned<ul style="list-style-type: none"><li>– Type of construction contract is important</li><li>– Contractors know how to manage risks</li><li>– Industry expertise is important and accessible</li><li>– Large tunnels are more expensive and time consuming to construct</li></ul></li></ul>

- The type of construction contract is important. Underground construction worldwide uses competitive processes, normally involving fixed-price contracts. Cost-plus contracts, such as used by the DOE for the ESF, have no known precedent in underground construction and provide little, if any, incentive for efficient, cost-effective construction.
- Contractors know how to manage the risks associated with equipment design and performance. Design, procurement, and disposal of construction equipment, including tunnel-boring machines, normally are left to the construction contractor. Specifications, such as for hydraulic spill mitigation, dust control, and safety requirements, can be defined and enforced without telling the contractor how to perform.
- Industry expertise is important and accessible. In 1995, after experiencing severe difficulties in excavating the ESF, the DOE, in conjunction with its contractor, established a consulting board. This board was very effective in achieving improvements, and the DOE is commended for involving outside expert consultants.
- Large-diameter tunnels are more expensive and time consuming to construct than small-diameter tunnels. The design for a Yucca Mountain repository includes large (7.6-m diameter) tunneling for service tunnels and the exhaust drift. Smaller tunnels would be affected much less by the high fracture density of the rock in the repository horizon and would be much more constructible than the large proposed tunnels.

## East-West (ECRB) Tunnel

The Board previously recommended excavation of an east-west exploratory tunnel at the elevation of the repository and parallel to the proposed emplacement drifts. The principal focus of this tunnel would be to obtain data to reduce the uncertainty of the hydrogeologic environment within the repository. The DOE has accepted this recommendation in general, but has expanded the scope to what is known as the "enhanced characterization of the repository block" (ECRB) program, which consists of the tunnel and two boreholes, to be drilled from the surface. All excavation, including three alcoves off of the tunnel, will be completed by January 1, 1999.

The next slide illustrates conceptually, although not to scale, the location of the ESF, the east-west tunnel, the potential repository, and some of the more prominent geologic features of the site. The Board supports the decision by the DOE to excavate the east-west tunnel expeditiously. Although hydrogeologic testing may not start until 1999, observations, mapping, and limited data on chlorine-36 ( $^{36}\text{Cl}$ ), which would indicate possible fast flow paths for water moving through the mountain, may be available before the scheduled delivery date for the VA, thus providing valuable confirmatory data for the VA.

## Thermal Testing at Yucca Mountain

One of the primary functions of the ESF is to provide access to the strata in which the repository is to be located to conduct thermal testing, especially the effects of repository heat on movement of water within highly fractured, unsaturated rocks. Data from thermal testing will be useful for validating the various hypotheses and assumptions used in developing performance models and the current repository design. Two tests are being conducted in the ESF, the single-heater test and the drift-scale test.

The "single-heater test" has been in its cool-down phase since May 1997, and all testing was to be completed by the end of January 1998. Post-test analyses within this portion of the ESF are planned, and key information should be available for incorporation into the viability assessment.

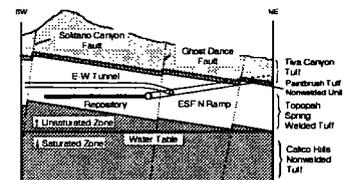
The "drift-scale test" is located in a 47.5-m-long (156 ft) test area equipped with heaters that simulate the thermal conditions of waste packages in a repository. On December 3, 1997, heaters were turned on and data collection was begun from sensors in the surrounding rock mass.

### Technical and Scientific Developments (cont'd)

#### East-West Tunnel

- DOE has accepted the Board's recommendation
- Two boreholes will also be drilled
- Should help reduce uncertainties about hydrologic conditions in the potential repository block

### Location of East-West Tunnel, Repository, and Geologic Features



### Technical and Scientific Developments (cont'd)

#### Thermal Testing

- Single-heater test in cool-down phase
- Drift-scale test started - simulates waste packages in a repository drift
- Large-block test nearing completion

The heating phase is planned to last approximately 4 years, with nominally 4 years for cooling afterward. The DOE is to be commended on implementing this extensive and important thermal test facility.

The "large-block test" is an additional thermal test being conducted on the surface near Yucca Mountain on an excavated outcrop of welded tuff. It was designed to promote formation of reflux (heat-pipe) zones as heat is applied to the bottom of a large block of fractured rock. Water, mobilized as vapor, is expected to be driven out of the pores of the rock and to flow upward where it will condense in cooler regions of the rock. The condensate then will return as reflux to the above-boiling zone. On February 28, 1997, the heaters were turned on, and the test was nearing completion at the end of 1997.

### ***What Happens When Radioactive Waste Reaches the Water Table?***

Late in 1997, the Board visited Yucca Mountain and nearby Amargosa Valley for field observations about the flow of groundwater between Yucca Mountain and Amargosa Valley, how groundwater conditions varied in the past as the climate varied, and how any radioactive materials released to the groundwater might, in the future, enter the human biosphere through seeps, springs, or withdrawal through wells.

#### **What Happens When Radioactive Waste Reaches the Water Table?**

- Groundwater flow in the saturated zone may be highly "channelized," limiting dilution and retardation
- Dilution may occur as water is withdrawn through a well
- Use of generic data in biosphere models may cause large uncertainties in dose estimates

Estimates of the concentrations of radioactive materials entering the environment south of a Yucca Mountain repository will be highly uncertain. The saturated zone is highly fractured and faulted, causing groundwater flow to be "channelized" within the more transmissive zones of fractured rock. Within these zones, groundwater movement will be faster than the average groundwater flow rate through the saturated zone, and retardation of radionuclides may be less than average. Mixing of groundwater containing radionuclides and radionuclide-free groundwater within the saturated zone will dilute radionuclide concentrations, but demonstrating the degree to which mixing would occur in a channelized flow system may prove very difficult.

An important, and perhaps greater, source of dilution may be mixing at a wellhead (or a spring) when groundwater leaves an aquifer and enters the biosphere. This depends on the specifics of the well withdrawal. Dilution by flow and transport in the saturated zone is difficult to quantify. Because of its significance in determining the relative importance of the different factors affecting dilution, an early definition of the well-withdrawal scenario could provide an important focus for studies at Yucca Mountain.

The fate of radionuclides after they enter the biosphere and as they enter food chains and potentially cause radiation doses to humans must be projected. The use of generic data in models of the transfer of radionuclides through food chains may cause large uncertainties in estimated radiation doses, perhaps as much as three or four orders of magnitude.

## **DOE Use of Outside Experts**

The Yucca Mountain project is receiving valuable advice from two DOE-funded external review groups: the TSPA Peer Review Panel and the Yucca Mountain Site Characterization Project Mined Geologic Disposal System Consulting Board. In the past, the Board has urged the DOE to make greater use of expertise outside of that already found within the Yucca Mountain program, and the Board is pleased that the DOE is doing so.

### DOE Use of Outside Experts

- Yucca Mountain project has review groups
  - TSPA Peer Review Panel
  - Disposal System Consulting Board
- Elicited expert judgment has been obtained on a number of topics
  - Provides information useful for design and analysis
  - Challenges hypotheses and views within the program

The Board's 1997 Summary Report discusses another type of external input: recent, specially elicited expert judgment. Expert judgment is required when dealing with an inherent uncertainty in scientific understanding or when there is a need to make an assessment before all relevant data can be collected. An example of the latter is the TSPA for the VA. Although informal implicit or explicit expert judgment from one or more Yucca Mountain scientists has always been used in performance assessment, the recent elicitations are formally structured studies that involve multiple experts, most of whom are from outside the Yucca Mountain program. The topics covered by the expert studies (some of which are not yet complete) include seismic and volcanic hazards, unsaturated-zone flow, waste package degradation, saturated-zone flow and transport, near-field/altered-zone coupled effects, and waste form degradation and radionuclide mobilization. A primary purpose has been to describe the uncertainties associated with particular models and data.

Overall, the elicitations have proven very successful. The DOE is commended for carrying out these studies and, in particular, for including a substantial number of outside scientists and engineers on the expert panels. Aside from supplying information that can be used directly for performance assessment and design, the elicitations have provided important insights into the program. They include the endorsement or rejection of previously accepted scientific models and design assumptions; the importance, or lack thereof, of different hypotheses; and the need to acquire selected additional data. The challenge to the DOE is to make full and effective use of the experts' input.

In making full and effective use of the expert elicitations, the DOE needs to articulate how it intends to aggregate the views of multiple experts and address the potential problems posed by receiving input on some issues from only a small number of the experts who were asked. This is especially important when there are relatively few experts and they differ sharply on meaningful issues. Sufficient information must be presented to trace the effect of an individual expert's judgment on overall conclusions. The DOE needs to explain whether and how the views of individual experts will be treated in sensitivity studies for the TSPA-VA, and it also should consider developing guidelines on how it will treat the results of an expert elicitation in the light of new data and analyses.

This concludes our prepared presentation. We will be happy to answer any questions you may have.