

Appendix F

Communications Between the Board and the OCRWM

In addition to published reports, the Board periodically writes letters to the Director of the DOE's Office of Civilian Radioactive Waste Management (OCRWM). These letters typically provide the OCRWM with the Board's views on specific technical areas sooner than do Board reports. The letters are posted on the Board's Web site after they have been sent to the OCRWM. For archival purposes, the three letters written during calendar year 1998 are reproduced here

The OCRWM typically responds to the Board's reports and letters, indicating its plans to respond to the Board's recommendations. Included here are the OCRWM's responses received by the Board during calendar year 1998. Inclusion of these responses does not imply the Board's concurrence.

- Letter from Chairman Jared L. Cohon to Lake H. Barrett, Acting Director, OCRWM; January 12, 1998.
Subject: Board comments on October 1997 Board meeting and Board panel meetings and field trips held in October, November, and December 1997.
- Letter from Chairman Jared L. Cohon to Lake H. Barrett, Acting Director, OCRWM; April 7, 1998.
Subject: Board comments on January 1998 Board meeting.
- Letter from Chairman Jared L. Cohon to Lake H. Barrett, Acting Director, OCRWM; July 30, 1998.
Subject: Board comments on June 1998 Board meeting.
- Letter from Lake H. Barrett, Acting Director, OCRWM, to Chairman Jared L. Cohon; May 11, 1998.
Subject: Response to January 12, 1998 Board letter.
- Letter from Lake H. Barrett, Acting Director, OCRWM, to Chairman Jared L. Cohon; May 19, 1998.
Subject: Response to the Board's *Fifteenth Report*.
- Letter from Lake H. Barrett, Acting Director, OCRWM, to Chairman Jared L. Cohon; June 15, 1998.
Subject: Response to April 7, 1998 Board letter.
- Letter from Lake H. Barrett, Acting Director, OCRWM, to Chairman Jared L. Cohon; September 8, 1998.
Subject: Response to the Board's *Report to The U.S. Congress and The Secretary of Energy: 1997 Findings and Recommendations*.
- Letter from Lake H. Barrett, Acting Director, OCRWM, to Chairman Jared L. Cohon; October 19, 1998.
Subject: Response to July 30, 1998 Board letter.



UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD

2300 Clarendon Boulevard, Suite 1300
Arlington VA 22201-3367

January 12, 1998

Mr. Lake H. Barrett
Acting Director
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
1000 Independence Avenue, SW
RW-2/5A-085
Washington, DC 20585

Dear Mr. Barrett:

The Nuclear Waste Technical Review Board (Board) would like to thank you and your staff and contractors for participating in several Board events during the last three months. During that time, the Board held one full Board meeting, three panel meetings, and one field trip. In my opening remarks at the October Board meeting, I indicated that the Board would provide feedback to the Office of Civilian Radioactive Waste Management (OCRWM) after each of its meetings. The comments below are offered in that context.

Comments from the Board's October Meeting

The Board's fall meeting focused on designs of the repository and the waste package that will be included in the viability assessment (VA) of the Yucca Mountain site.

1. Alternative Designs. The design options discussed at the Board meeting appear to involve "add-ons" (e.g., drip shields) to the existing reference designs. The reference waste package design and the reference repository subsurface design seem to have changed very little over the years, even though data obtained from the exploratory studies facility (ESF) in the last two years indicate that the repository may be "wetter" than originally thought. Although the discovery of possible fast pathways for infiltrating precipitation has triggered examination of other design options, these options have not been incorporated in the reference designs.

In addition to evaluation of design add-ons, we believe the program would benefit from serious study of other repository and waste package designs that represent alternatives to the reference designs. Examples of design concepts that could be explored include some or all of the following: (1) a design in which the boiling fronts do not coalesce between drifts; (2) a design permitting humans wearing typical work clothing to safely enter emplacement drifts containing

preclosure or postclosure ventilation or both, based on natural convection, forced convection, or a combination of both; and (5) a waste package design using two corrosion-resistant materials. Each concept for repository design should address all thermal constraints *and* accommodate at least 70,000 metric tons in the current repository footprint.

We realize that these ideas—and many others—are not new to the program. We are not aware, however, that they have received a thorough and objective evaluation that considers new hydrologic data obtained from the site. The Board believes that including alternative repository and waste package designs in the VA is a good idea, although it is clear that alternatives will not be as fully developed as the reference case. In particular, we think it is vital that the VA that is conveyed to Congress includes alternatives that show an array of cost-versus-performance choices.

2. Remote operations and ventilation. We understand that the current design basis assumes that humans will not be allowed in emplacement drifts containing one or more waste packages and that all operations of emplacement, retrieval, monitoring, and maintenance in such drifts will be totally automatic. Although this design basis appears to be unprecedented for underground operations having durations of up to a century, temperatures ranging from ambient to several hundred degrees, and severe radiation fields, it is not technically infeasible. What is clear, however, is that a technical development program will be needed to demonstrate and debug the equipment and the control and communication systems necessary for implementing the design basis for underground operations. The costs of and the potential for problems with these remote systems should be recognized in the VA.

Given the current size and number of exhaust shafts, the rationale for including the north-south exhaust drift that runs underneath the repository is unclear. Assuming that the east, south, west, and north main drifts have the same diameter, it appears that the same amount of ventilation could be accomplished with or without the north-south exhaust drift. Also unclear is why the current design calls for the exhaust drift to be constructed below rather than above the repository. In any case, the repository design should take advantage of the density difference between the warm exhaust air and the cooler intake air to maximize preclosure heat removal by natural convection.

3. Galvanic protection and waste package fabrication. Presentations made at the meeting raise questions about whether the performance assessment and engineering design groups are using the same approach to galvanic protection for the base case of the VA. Specifically, it seems that (1) the performance assessment group intends giving little or no performance credit for galvanic protection in its VA base case and (2) the engineering designers assume that the waste package design for the VA base case *will* provide galvanic protection. Recently, both the Waste Package Expert Elicitation Project and the Total System Performance Assessment (TSPA) Peer Review Panel presented opinions that galvanic protection is likely to provide no more than several hundred years of additional protection. It is unlikely that data will be obtained and analyzed between now and the VA delivery date that will either refute or confirm these opinions with any degree of confidence. Therefore, we believe that a prudent course of action would be to omit galvanic protection entirely for the base case of the VA or to rely on it for no more than a few hundred years. At the same time, we realize that galvanic protection has significant potential, and we encourage continued experimental work in the area and sensitivity studies in VA cases other than the base case.

The Board agrees with information presented at the October Board meeting indicating that shrinkfitting is technically feasible and that it is not a costly operation in itself. However, unless the parts to be mated are machined with a high degree of precision, the residual stresses from the shrinkfitting will be variable. Concerns have been expressed that the residual stresses left from shrinkfitting could exacerbate corrosion of the waste package or cause other unknown stress-related problems. As we understand it, the principal, perhaps the only, justification for shrinkfitting is to promote galvanic protection. Because the additional performance that galvanic protection will provide is considered limited, we question whether shrinkfitting should be included in the VA.

In addition, the Board has long been concerned, as have people within the program, about the inspectability of final closure welds (the welds made after waste has been placed in the package) of both the inner and the outer shells. We believe that this issue is completely resolvable and that its resolution may be postponed to well beyond the delivery date of the VA. However, we think it important to point out that the shrinkfit design makes the final closure welds, particularly those of the inner shells, difficult to inspect.

4. *Independent cost estimate.* The Board was pleased to learn that an independent cost estimate (ICE) of the mined geologic disposal system (MGDS) will be performed for the VA by a major U.S. engineering-construction firm. The Board is particularly interested in techniques, allowances, and contingencies the ICE provider will use to show technology-development costs (e.g., manufacture of prototype waste packages, development and testing of robotics systems for remote emplacement and monitoring) and to accommodate current technical uncertainties (e.g., alignment of emplacement drifts). We also would like to know how the ICE will address potential enhancements to the MGDS that are not part of the base case design. We believe that it is important for the Board to understand the approach being used for the ICE. We would appreciate receiving a copy of the statement of work from the contract with the ICE provider, as well as copies of task orders or other amendments to the statement of work as they are developed.

5. *ECRB and performance confirmation.* We thank you for sending the documentation for the planning effort for the enhanced characterization of the repository block (ECRB). We understand that some data from the ECRB will be available before the VA is delivered. We would like to know how the data could or would be used in the VA. Because data from the ECRB could be critical, we would appreciate your providing future ECRB plans and developments to the Board as they become available.

Comments from Board Panel Meetings and Field Trip

In addition to the Board's fall meeting, held on October 22-23, 1997, the Board sponsored three panel meetings and one field trip in the last 11 weeks. The Board's Panel on the Environment, Regulations, and Quality Assurance held a meeting on October 21 on the DOE's interim performance measure for a Yucca Mountain repository; the Board's Panel on the Waste Management System held a meeting on the safety of spent-fuel transportation on November 19-20; and the Board's Panel on the Repository held a meeting on December 17 on the disposal of highly enriched aluminum-clad spent fuel. On December 3-4, a number of Board members and staff took part in a field trip to Amargosa Valley, during which we were briefed on several biosphere issues and toured the ESF. We are providing some limited feedback from each of these activities.

First, we are concerned about the DOE's exclusion of children from the definition of the critical group in the interim performance measure. If the exclusion is viewed by others as an attempt to bias downward the dose estimates for a Yucca Mountain repository, the DOE's credibility could suffer. The DOE should include in the VA estimates of the likely doses for children as well as adults.

Second, despite the high degree of public concern about transportation of spent fuel and high-level waste, the DOE's recent efforts in the transportation area have been limited essentially to the privatization of much of the transportation function. The Board's view is that there may be difficulties in implementing this approach as it is now envisioned and that developing contingency plans would be prudent.

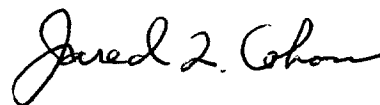
Third, several members of the Board had the opportunity to look over the drift-scale thermal test facility during their December 4 tour of the ESF. The Board is very pleased that drift-scale thermal testing has begun and considers the planning, design, construction, and start-up of the facility in less than two years a remarkable accomplishment. We share in the hope that the facility will provide valuable data for increasing understanding of the implications of various thermal loads for repository and waste package performance. The Board congratulates all involved on this well-integrated effort.

Finally, the OCRWM should carefully consider its technical bases for accepting highly enriched aluminum-clad spent fuel (essentially all of which is from domestic and foreign research reactors) for disposal in a repository at Yucca Mountain. Compared with commercial spent fuel, highly enriched aluminum-clad spent fuel is a waste form that degrades faster, leading to greater long-term doses on a ton-for-ton basis, and that may heighten concerns about criticality control.

To provide the rapid feedback we promised, we are furnishing the foregoing, which contains preliminary and formative thoughts. Accordingly, it seems inappropriate for the Board to request or expect a written response—although your informal reactions would be welcome. It is reasonable to expect that the views of many Board members and staff over the next few months will reflect the points articulated in this letter.

Thank you for your personal participation in our Board meetings and the participation of your staff and contractors. The Board hopes that this letter is helpful.

Sincerely,



Jared L. Cohon
Chairman



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NUCLEAR WASTE TECHNICAL REVIEW BOARD
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April 7, 1998

Mr. Lake H. Barrett
Acting Director
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U.S. Department of Energy
1000 Independence Avenue, SW
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Dear Mr. Barrett:

On behalf of the Nuclear Waste Technical Review Board, I would like to thank you and your staff and contractors for participating in the Board's January 1998 meeting. In particular, we appreciate your response to the points raised in the Board's recent letter report to Congress and the Secretary of Energy and your effort to make yourself available throughout the entire public-comment session on the first day of the meeting.

This letter provides the Board's comments on the January meeting and reflects our ongoing effort to provide feedback to the Office of Civilian Radioactive Waste Management (OCRWM) after Board meetings. The Board's January meeting focused on site-characterization activities related to the saturated zone (SZ). The OCRWM also presented an overview of the status of the environmental impact statement (EIS) for the proposed repository and provided a brief update on thermal testing activities at the site.

Presentations on Characterization of the Saturated Zone

The Board was particularly interested in SZ site-characterization activities that have been completed and activities that are under way related to the SZ, including the hydraulic and tracer studies at the C-well complex, the geochemical and isotopic age-dating data on the SZ water, the regional studies of discharge areas, the influences of climate and population changes, and the effects of increased groundwater withdrawals. The Board looks forward to receiving updates on the data obtained from these ongoing studies and learning more about the detailed plans for the second C-well-type complex for larger-scale hydraulic and tracer testing of the SZ, the regional geochemical studies, and the proposed well(s) for investigating the large hydraulic gradient north of the proposed repository. (The Board also will be interested in receiving progress reports on the studies of transport in the unsaturated zone being conducted at Busted Butte.) The Board believes that a review of these proposed test plans by an outside technical panel like the one convened for the expert elicitation on the SZ would be beneficial for the project.

These studies should provide much useful information. However, it is clear that answering questions about the effects of molecular diffusion, hydrodynamic dispersion, and sorption on dilution in the SZ will be difficult. The most direct way to obtain answers to these questions would be to perform large-scale tracer tests. However, such tests may be impractical because it could take many years for the tracers to travel from Yucca Mountain to the monitoring wells. Although some data may be obtained from the proposed SZ well complex, which will be located south of the proposed repository, uncertainties will remain about the dilution that the SZ can provide.

Expert Elicitation on the Saturated Zone

The Board is pleased that the DOE convened an expert panel for quantifying key uncertainties in the SZ studies. Several of the panel members expressed doubt about whether a large amount of dilution could occur in the SZ. Those panel members noted that present modeling of the dilution processes in the total system performance assessment for the viability assessment (TSPA-VA) assumes an optimistic and, indeed, unsubstantiated amount of mixing of waters and thus an unsubstantiated increase in dilution. The Board is deeply concerned that such a high mixing factor and so few data to back up that assumption could raise challenges in the future. The Board believes that the DOE should use dispersion-dilution models in the reference case TSPA-VA that are more in accord with the expert opinions.

The Board is pleased with the program's progress in integrating available data and expert opinions into modeling of the *unsaturated* zone. However, we concluded from the presentations on the SZ modeling that far more model integration and reality checking using data obtained from the site need to occur before these models can be viewed as credible and robust. It appears that the researchers involved in modeling the SZ are using several hydrologic models that may not be consistent with each other and that very few data are available to develop, bound, and validate models of the SZ.

Presentation by the State of Nevada's Contractor

A contractor for the state of Nevada, Linda Lehman, presented an interesting conceptual model of SZ flow. Her model, which is based on temperature data and was developed using uncomplicated modeling techniques, correlates SZ flow with fault zones and other features of the site. The OCRWM should carefully review her findings, if it has not already done so.

The EIS

The Board believes that the session outlining the OCRWM's plans for preparing an EIS provided the opportunity for a useful exchange of views and information. We would like to thank you for ensuring that the Board will have access to all requested information. The Board noted that the EIS presentation did not include essential analyses of alternative designs for the repository and waste package that should normally be part of any National Environmental Policy Act process. Without these analyses, the OCRWM will have difficulty making its case that all "reasonable" alternatives have been examined. The Board believes that ensuring that the EIS is technically defensible and tightly reasoned should remain a high program priority.

Thermal Testing Update

Significant uncertainty persists about the thermo-hydrologic response of Yucca Mountain to high temperatures and the resulting waste package environment during a period of high temperatures. Thus, progress on the thermal tests remains absolutely vital to site characterization. The Board believes that the single-heater and drift-scale heater tests have been well planned and executed and that the results are being analyzed appropriately.

To provide feedback in a time frame that will be useful to the OCRWM, we are furnishing the foregoing preliminary and formative thoughts. Accordingly, it seems inappropriate for the Board to request or expect a written response—although your informal reactions would be welcome. We thank you again for the time you spent at the meeting and for your attention to the comments in this letter.

Sincerely,

A handwritten signature in cursive script that reads "Jared L. Cohon".

Jared L. Cohon
Chairman



UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
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July 30, 1998

Mr. Lake Barrett
Acting Director
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Dear Mr. Barrett:

I am pleased to forward the Board's comments on the June 1998 meeting, which all the members felt was very productive and stimulating. The Board was pleased that you were able to join us for the field trip to Yucca Mountain and the Nevada Test Site and that you attended the entire meeting. Bob Andrew's presentation was even better than the one he gave to our Panel on Performance Assessment in April. Holly Dockery's demonstration slide show is a promising approach for making total system performance assessment (TSPA) more transparent. Claudia Newbury also deserves special credit for coordinating the Office of Civilian Radioactive Waste Management's (OCRWM) participation and for planning the informative field trip.

We have some specific impressions about the presentations, as well as some thoughts on issues that arose during the meeting.

Total System Performance Assessment. Bob Andrew's latest presentation shows that the OCRWM continues to refine its thinking about the TSPA being developed for the viability assessment. This latest analysis leaves the clear impression that the projected performance of the repository system is highly dependent on the corrosion resistance of the waste package.

Any set of calculations, however, is only as valid as the underlying assumptions, models, and data used. For example, the uncertainty analyses were highly dependent on the *assigned* uncertainty. Important issues, such as cladding performance, did not appear important only because they were assigned a low uncertainty. Also not evident was whether the correlation between parameters, such as infiltration and seepage fraction, had been taken fully into account.

The Board recognizes the need to make judgments in any analysis. However, these judgments and their bases need to be stated explicitly and clearly. In 1997, the Board provided a number of suggestions on how TSPA could meet this and other challenges. These suggestions appear in the Board report on its 1996 activities (March, 1997) and in a letter sent to April Gil (April 15, 1997) in response to the OCRWM's request for comments on proposed revisions to 10 CFR 960. In that report and letter, the Board laid out some suggestions on how to prepare a

technically persuasive and robust performance assessment. We believe that the OCRWM's assessments should increasingly incorporate those ideas.

License Application Plan. The Board was pleased with Jack Bailey's presentation because it showed the beginnings of a systematic effort to assess technical priorities. He laid the groundwork for a methodology to identify the critical research that needs to be conducted before a site recommendation and the possible submittal of a license application to the Nuclear Regulatory Commission. This information is helpful. The Board believes, however, that the OCRWM needs to define key measures of knowledge, uncertainty, and value more rigorously. It also needs to make its decision-aiding methodology more transparent.

Determination of Importance Evaluation (DIE) on the East-West Crossing. The Board reviewed the latest revision to the DIE. It believes that the OCRWM has not addressed adequately mountain-scale coupled thermal, hydrologic, and mechanical (THM) processes. The Board has not seen any rigorous THM analysis of whether the east-west crossing will affect long-term repository performance or will foreclose repository design alternatives. Nor has the Board seen evidence that efforts are planned in this area. The Board, once again, urges the DOE to carry out a systematic study of the potential effect of the east-west crossing.

Observations from the Field Trip. The Board was impressed with the speed at which the Busted Butte experiment was conceived, designed, and constructed. Data from this effort could reduce some of the significant uncertainties in understanding how radionuclides are transported in the unsaturated zone matrix below the repository horizon. The data also could strengthen the conceptual foundation of the performance assessments. If the project has not already done so, it should examine work on plutonium and colloidal transport that was carried out at Hanford as part of the Basalt Waste Isolation Plant (BWIP).

The Board believes that tunnels at the Nevada Test Site, such as the N-tunnel, could provide information on the percolation flux above the repository horizon in the unsaturated zone under conditions of higher precipitation. The data might be quite useful in modeling repository performance under pluvial conditions.

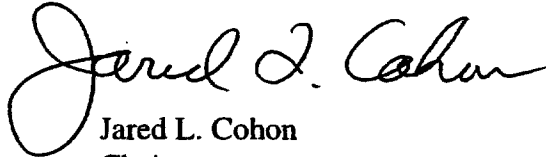
Environmental Impact Statement. The Board's concerns about the alternatives to be analyzed in the draft environmental impact statement for the repository were not reduced by Wendy Dixon's presentation. Two conclusionary statements were made in the presentation to the effect that the implementing alternatives "bracket" the relevant environmental impacts. No technical basis was given for those statements despite the Board's specific request that all technical analyses dealing with the choice of alternatives be presented. We look forward to being provided with additional information on this issue.

Alternative Repository Designs. Michael Voegelé presented a plan for examining alternative configurations before selecting a repository design that the OCRWM will carry forward to site recommendation and license application. The Board is pleased that the OCRWM has made this commitment. The Board is concerned, however, that, according to budget figures available to it and the current level of project activities, this examination may not be as comprehensive as the Board believes it ought to be and that it might not be completed in time to play a meaningful role

in the May 1999 design decision. The Board reemphasizes the importance it attaches to a full-scale systems engineering analysis. Such an analysis should evaluate alternative system concepts incorporating various combinations of repository and waste package features, including, but not limited to, restricting peak temperature to below 80° C, long-term ventilation, and the location of the corrosion-resistant layer in the waste package design. Again, if the project has not already done so, it should examine work in this area done at the BWIP.

In closing, I congratulate you and your staff for putting together a meeting containing such a high level of technical content. The exchanges between the Board and project participants were enlightening and significant. Again, I thank you.

Sincerely,

A handwritten signature in black ink that reads "Jared L. Cohon". The signature is written in a cursive style with a large, looping initial "J".

Jared L. Cohon
Chairman



Department of Energy

Washington, DC 20585

May 11, 1998

MAY 14 1998

Dr. Jared L. Cohon
Chairman
Nuclear Waste Technical Review Board
2300 Clarendon Boulevard
Arlington, Virginia 22201-3367

Dear Dr. Cohon:

The Department of Energy appreciates the Nuclear Waste Technical Review Board's new initiative in providing preliminary comments following its meetings. This timely feedback will help the Department manage the ongoing work by providing early insights into the Board's perspective on technical issues. To ensure that important issues are being addressed appropriately, the Department would like to provide the Board with responses to its comments. The enclosure is our response to your letter of January 12, 1998, with the Board's comments from the October 1997 meeting, three panel meetings, and one field trip.

We continue to value the Board's feedback as we pursue completion of the viability assessment and the future work beyond. If you have any questions, please contact me at (202) 586-6842.

Sincerely,

A handwritten signature in black ink, appearing to read "Lake H. Barrett".

Lake H. Barrett, Acting Director
Office of Civilian Radioactive
Waste Management

Enclosure



**DOE Response to Comments
of the Nuclear Waste Technical Review Board
from its October 1997 Meeting**

Alternative Designs

As explained at the Board's meeting in Amargosa Valley in January 1998, the Department is preserving flexibility to ensure that design alternatives identified in the viability assessment (VA) for the engineered barriers, as well as those that emerge with advancements in technology, can be accommodated in the repository development process. The Department agrees that the repository and waste package designs should not be prematurely fixed and that other potential alternatives, such as those suggested by the Board, should not be foreclosed. As pointed out by the Board, design alternatives should be reevaluated as relevant new data become available. We expect that design alternatives will continue to be evaluated throughout repository licensing, construction, and operation. As modifications to the reference design and concept of operations are proposed and analyzed, the Department will share those with the Board.

For the VA, the Department is addressing the feasibility of geologic disposal at Yucca Mountain by focusing on a reference design concept which is only one of a number of workable concepts. This reference design and an assessment of its performance provide the frame of reference necessary to evaluate the sufficiency of site characterization data and analyses. The VA will include qualitative analyses of design alternatives and plans for further evaluation of alternatives before submittal of the license application. The VA will not include cost estimates or performance assessments for the design alternatives.

Remote Operations and Ventilation

The Department agrees with the Board on the need to develop and demonstrate systems for remote operations in the repository. However, the detailed designs of these systems are not critical to the VA, because the main components of the subsurface waste transportation and emplacement systems use existing technology. No additional research needs have been identified. The VA design description will contain discussion of the remote systems, including limited information on failure modes and responses. The detailed design work will be undertaken at the appropriate time after the VA and shared with the Board. As suggested by the Board, the estimated costs of such systems, including contingencies for potential problems, will be included in the VA.

The Board questioned the need for and location of the north-south central main exhaust drift and suggested taking advantage of natural convection. In the reference design, air flows from the east and west mains toward the center of the block, enters the central main exhaust drift, and is carried in the exhaust drift to the exhaust shaft. The use of a central exhaust allows both the east and west mains to be used for intake, or fresh air mains. The benefit of the central main exhaust is that it reduces the length of the emplacement drifts that needs to be ventilated by a single intake from a maximum of approximately 1,200 meters to about 600 meters. This reduction in length shortens the maximum travel and communications distance between the remote equipment and the

drift entrance, and also enables faster “cooldown” of drifts where wastes have been emplaced, if re-entry is required.

The rationale for the location of the central main exhaust drift is based on post-closure water movement. One design objective is to avoid placing any non-emplacment drift in a position such that, if water enters that drift, it could pass directly through a man-made opening into an waste emplacement area. Other drifts above the emplacement areas, such as performance confirmation drifts, are not directly connected with man-made openings to the underlying emplacement area and are laid out to have a consistent gradient which will promote gravity drainage away from emplacement areas. The central main exhaust drift must, because of its function, be directly connected to the emplacement drifts. For this reason, it was placed below the emplacement area.

Regarding the utilization of natural convection, the location of the central main exhaust above or below the emplacement block will have little impact on the magnitude of natural ventilation pressure developed by the repository system. The dominating factor in the determination of the natural ventilation pressure is the depth of the emplacement exhaust shaft. This shaft is over 400 meters deep, and it is the density of this column of warm air compared to a similar column of air with characteristics of the outside atmosphere which will determine the natural ventilation pressure. Whether the exhaust main is 10 meters below, or 10 meters above, the emplacement block will have no more than about a 5 percent impact on the magnitude of natural ventilation pressure.

Galvanic Protection and Waste Package Fabrication

The Department agrees with the Board that there are unresolved issues with demonstrating the value of galvanic protection. Accordingly, the Department considered the input received from our outside experts along with our testing information to determine the level of credit for galvanic protection defensible for the total system performance assessment (TSPA) for the VA. The decision has been made that credit for galvanic protection is not being included in the TSPA-VA base case calculation.

As the Board has noted, galvanic protection has significant potential. Therefore, the Department has initiated experiments that could provide the results needed to take credit for galvanic protection in the license application, if needed.

In completing TSPA-VA, the performance assessment staff are using a design baseline to ensure that the design assumptions in performance assessment are consistent with the engineering design assumptions. This formally controlled process is structured to avoid disconnects between engineering design and performance assessment.

The concerns expressed by the Board on residual stress from shrink-fitting of the two cylinders constituting the inner and outer waste package barriers are understood and are being investigated. Shrink-fitting is being considered for ensuring that the two cylinders do not move relative to each

other, in addition to its potential benefit for providing some galvanic protection of the inner barrier. Preliminary calculations of the additional stress imparted to the waste package barrier system as a result of shrink-fitting have shown that the stress is well below the level that would cause stress corrosion cracking in the inner barrier. Shrink-fitting is being further investigated during Fiscal Year 1998.

The Board's concerns on the inspectability of final closure welds will be fully addressed before selecting the final fabrication and welding processes. The inspection by ultrasonic testing of the inner barrier on the Fiscal Year 1997 waste package mock-up was successfully accomplished. The inspectability of the inner weld by remote ultrasonic testing will be further investigated during Fiscal Year 1998.

Independent Cost Estimate

The Department appreciates the Board's interest in the independent review of the cost estimate of repository construction, operation, and closure. The VA cost estimate is being externally reviewed by Foster Wheeler, a major U.S. engineering-construction company. Foster Wheeler's scope of work is limited to an evaluation of project cost estimating assumptions, methodologies, and bases of estimates associated with the VA base case design. The review includes examination of estimates relating to waste packages, surface and subsurface facilities, and performance confirmation, as well as related project development and evaluation costs. Foster Wheeler will be preparing individual assessments of these cost segments, as well as a summary report. Foster Wheeler initiated its review in October 1997 and is scheduled to complete all cost segment reviews by May 1998. The summary report, expected in June 1998, will address Foster Wheeler's findings on each VA cost estimate segment and its integration into the overall cost summary.

The Department provided the Board with the statement of work for Foster Wheeler on April 8, 1998.

Enhanced Characterization of the Repository Block and Performance Confirmation

We understand the Board's desire to see the data collected from the Enhanced Characterization of the Repository Block (ECRB) initiative included in the VA. Construction of the cross-drift will be completed about the time that the VA will be completed. We expect that observational data collected during the construction of the cross-drift will be included to the extent practicable. This data could include identification of faults that are exposed in the cross-drift and preliminary information on fracture distributions. It is not likely that there will be sufficient time to complete sample collection and analysis or in situ testing in the cross-drift prior to issuing the VA. The results of these investigations will be included in the site recommendation and license application. The Department will keep the Board informed on plans and developments for the ECRB and performance confirmation.

**DOE Response to Comments
of the Nuclear Waste Technical Review Board
from its Panel Meetings and Field Trip**

Definition of Critical Group

The Department recognizes the Board's concern regarding dose estimates to children. At this time, there are no Environmental Protection Agency (EPA), Nuclear Regulatory Commission (NRC), or Departmental radiation protection standards that specifically include children. Currently, regulatory practice is to estimate doses using physiological parameters developed by the International Commission on Radiological Protection, collectively known as the Reference Man. The dose conversion factors estimated based on the Reference Man have uncertainties that are comparable in magnitude to the uncertainties in exposure assessments and to the estimates of cancer risks.

For purposes of radiation protection, the Department concurs with EPA's and NRC's positions that the assumptions exemplified by the Reference Man adequately characterize the general public, and a detailed consideration of factors such as age and sex is generally not necessary. As the Board is aware, estimating doses to children and other age-specific groups is a complex task because of factors such as systemic biokinetic models, gastrointestinal uptake factors, organ masses and positions, and food consumption habits, all of which change as a person ages.

The Department will evaluate impacts to children in a technical report. The report will address the impacts to children and other age groups from a repository at Yucca Mountain. To estimate these impacts, the Department will use recently developed national and international guidance.

Contingency Plans for Transportation

The Department recognizes the public's concerns with the transportation of spent fuel. To identify and address potential difficulties in implementing our market-driven approach to transportation, the Department issued for comment a draft request for proposals in December 1996 and a revised draft in November 1997. In addition, the Department interacts regularly with a broad range of stakeholders on issues related to transportation. The Department will consider the input from these forums in developing its strategy for transportation and the need for contingency plans. In the meantime, we would welcome the Board's comments on the revised draft request for proposals.

Drift Scale Thermal Test Facility

The Department thanks the Board for its positive comments on the timely planning, design, and start up of the drift-scale thermal test.

Highly Enriched Aluminum-Clad Spent Fuel

The Department agrees with the Board that the effects on repository performance of accepting highly-enriched aluminum-clad spent fuel need careful consideration. The Department is addressing issues raised in your letter concerning long-term doses and criticality.

Although the aluminum-clad spent fuels degrade faster than zircalloy-clad commercial fuels, the burnup of the aluminum-clad spent fuel is less than the burnup of commercial fuels, leading to a lower source term for the long-term dose. Preliminary evaluations indicate that the relatively small amount of aluminum-clad spent fuel, with its smaller source term compared to the commercial fuel, does not have a significant impact on overall repository performance, even with the higher degradation rate.

The proposed design features and loading limits for the aluminum-clad spent fuel are expected to make criticality control for this fuel no greater a concern than for the commercial spent fuel.

The Department is developing acceptance criteria for disposal of Department-owned spent fuel, including the highly enriched aluminum-clad spent fuel, which will also address these waste form issues. We look forward to your review of these criteria.



Department of Energy

Washington, DC 20585

May 19, 1998

MAY 21 1998

Dr. Jared L. Cohon
Chairman
Nuclear Waste Technical Review Board
2300 Clarendon Boulevard
Arlington, Virginia 22201-3367

Dear Dr. Cohon:

This letter transmits the Department of Energy's response to the Nuclear Waste Technical Review Board's second report of 1997 to the U.S. Congress and the Secretary of Energy, also referred to as the Board's *Fifteenth Report*, that was issued on December 23, 1997. Our response to the Board's comments on several key issues is found in the enclosure.

The Department appreciates the Board's recognition of the considerable progress we have made in characterizing the Yucca Mountain site and our efforts to improve interactions between the Department and the Board. Additionally, we appreciate the Board's recognition of the well-integrated effort that resulted in the timely completion of the drift scale test facility and the initiation of important thermal tests. We look forward to continuing to receive the Board's evaluations as we pursue completion of the viability assessment. If you have any questions, please contact me at (202) 586-6842.

Sincerely,

A handwritten signature in black ink, appearing to read "Lake H. Barrett".

Lake H. Barrett, Acting Director
Office of Civilian Radioactive
Waste Management

Enclosure



**DOE Response to Comments on Several Key Issues
by the Nuclear Waste Technical Review Board in its
Second Report of 1997 to the U.S. Congress
and the Secretary of Energy, December 1997**

Viability Assessment

The Department agrees with the Board that the viability assessment (VA) is an important intermediate milestone on the path to an evaluation of site suitability rather than a decision point and should be kept in the proper context. We expect that the VA will provide information to facilitate intermediate evaluation of the potential Yucca Mountain Monitored Geologic Repository. The independent views of the Board will be important in this evaluation process. From the Department's perspective, the VA components will objectively describe the design, performance, and cost of a Yucca Mountain repository based on the information collected to date. The assessment will also include a proposed path forward for completing site characterization and developing a site recommendation and a license application (LA).

Repository and Waste Package Designs

The Department recognizes the advantages of using a robust engineered barrier system in combination with geologic barriers, as suggested by the Board. Our reference design includes a multi-metallic robust waste package that is projected to contain the waste for thousands of years in the repository environment.

As part of its ongoing design and analysis programs, the Department is developing design alternatives for the repository and the engineered barrier. We are preserving flexibility in the existing design approach to ensure that design alternatives now foreseen, as well as those that may emerge with advancements in technology, can be accommodated in the repository development process, as recommended by the Board. We expect that design alternatives will continue to be evaluated throughout repository licensing, construction, and operation. As modifications to the reference design and concept of operations are proposed and analyzed, the Department will share those with the Board.

A reference design, however, is essential for the VA, and a reference design will be essential for the rational completion of site characterization and the licensing process. Such a reference design and an assessment of its performance provide the frame of reference required to evaluate the sufficiency of site characterization data and analyses. This use of a reference design ensures that the components of the VA, and later key documents, relate to a coherent proposed facility and rely on consistent information. Consideration of significant alternatives to the reference design

will continue to be an important part of the design development process. Discussion of alternatives is required for the license application and will be included at a conceptual level in the VA.

Total System Performance Assessment

We recognize the importance of support from the scientific community at large for the Department's technical work. We appreciate the Board's strong support of our efforts to solicit the views of outside experts on the interpretation of data obtained in site characterization and the development of appropriate process models for use in total system performance assessments (TSPA). Expert elicitations in five focused subject areas have been conducted to help define and, where possible, quantify the uncertainties in parameters and models to be used in the TSPA-VA. These elicitation addressed: unsaturated-zone flow; waste package degradation; saturated-zone flow and transport; near-field and altered zone coupled effects; and waste form degradation. These elicitations are intended to supplement data collection and analysis by focusing on uncertainties in the currently available information. In each of these elicitations, the experts were asked to recommend additional data collection and analysis activities that, in their opinion, could lead to a significant reduction in the existing uncertainties. The Department will make full use of the information provided by the experts for evaluating predictive models and as a guide for future testing.

In addition to the focused input we receive from outside experts, we have formed an independent peer review panel to review the entire total system performance assessment process. This review is ongoing. We have received two interim reports from the panel, which are being used to improve our performance assessment process. The panel's final report will follow the VA and will influence how the Department proceeds with the performance assessment for the LA. The Department appreciates the interest that the Board has shown in the TSPA peer review process and encourages your continued participation as observers at the peer review briefings to the Department.

The Department agrees with the Board that expert elicitation is dependent on collected data and can guide additional data collection, but is not a substitute for reasonably obtainable data. We have structured our ongoing expert elicitations to be generally consistent with guidance from the Nuclear Regulatory Commission on the use of expert elicitation, which is also based in part on these premises.

Enhanced Characterization of the Repository Block

We appreciate the significance of hydrologic data that will come from studies in the cross drift that is being constructed as part of the enhanced characterization of the repository block. The construction of the starter tunnel for the cross drift is well under way, and the tunnel boring machine started boring on March 31, 1998, approximately three weeks ahead of schedule. Excavation is expected to be completed later this year.

The testing for the enhanced characterization of the repository block will continue for several years after excavations are completed; however, visual observations and mapping will be performed as excavation proceeds. The Department understands and agrees with the Board's desire to see included in the VA as much as possible of the data collected from the enhanced characterization of the repository block program. We expect that the observational data collected during construction will be included in the VA to the extent practicable. These data could include identification of faults exposed in the cross-drift and preliminary information on fracture distributions. It is not likely that there will be sufficient time to complete sample collection and analysis or in situ testing prior to issuing the VA. The results of these investigations will be included in the LA.

In addition to the cross drift, the Department is constructing an underground facility at Busted Butte in the Calico Hills formation to provide a test site in the same rock unit that exists below the western part of the proposed repository block. This testing is intended to reduce uncertainties in the Yucca Mountain Project's assessment of the potential transport of key radionuclides from the repository area, through the unsaturated zone, to the water table underlying Yucca Mountain. Tests also will address the importance of colloid-facilitated transport of radionuclides in fractured and unfractured rock. Underground construction began in mid-December 1997 and testing will continue through August 1999.



Department of Energy

Washington, DC 20585

June 15, 1998

JUN 17 1998

Dr. Jared L. Cohon
Chairman
Nuclear Waste Technical Review Board
2300 Clarendon Boulevard
Arlington, Virginia 22201-3367

Dear Dr. Cohon:

The Department of Energy appreciates the Nuclear Waste Technical Review Board's continuing effort to provide preliminary comments following its public meetings. To ensure that important issues are being addressed in a timely manner, the Department would like to provide the Board with preliminary responses to its comments of April 7, 1998, on the Board's January 1998 meeting. This meeting focused on studies of the saturated zone and the environmental impact statement.

Characterization of the Saturated Zone

We share the Board's interest in saturated zone (SZ) studies. Additional field tests are being planned in response to the importance assigned to SZ flow and transport in the repository safety strategy. The intent of these tests is to reduce the uncertainties about radionuclide dilution in the SZ. We will keep the Board informed of the results of ongoing studies and of plans for additional tests in the SZ. As the plans for additional tests are being formulated, we will also consider the Board's suggestion for a review of the plans by an outside technical panel.

Expert Elicitation on the Saturated Zone

The Board suggested that our SZ models assume an optimistic amount of dilution and that the current models need better integration and more supporting data. Based on the expert elicitation and other inputs, we have substantially revised and simplified the SZ model in TSPA-VA from that presented to the Board in January 1998. This has resulted in more realistic dispersion and therefore, much reduced dilution factors. We will include in the viability assessment (VA) a study on the sensitivity of repository performance to variations in the dilution factor. As was discussed earlier, the Department intends to conduct additional testing in the SZ after the VA to provide additional data to support the SZ models.

Presentation by the State of Nevada's Contractor

As suggested by the Board, the SZ flow model presented by the State's contractor is being reviewed as we continue development of SZ models. The Department recognizes the value of considering alternative models for ensuring that the full range of uncertainty is addressed.



The Environmental Impact Statement (EIS)

The Department welcomes the Board's interest in the EIS process and how alternative designs will be considered. Through the EIS, we intend to bound the environmental impacts from a reasonable range of designs, based primarily on a range of thermal loads. The impacts of other reasonable alternative designs should fall within these bounds.

As the Board mentions, the Department must at the appropriate time present a comparative evaluation of design alternatives. We expect that evaluation, which is required by the U.S. Nuclear Regulatory Commission (the Commission), to be initially developed for the VA and then to evolve throughout the preclicensing and licensing periods. The Department intends to use a workable reference design to support the development of a license application. We recognize that technological advances over the decades of repository construction and operation can be expected to influence design changes. Input from the Board, the Commission, and other interested parties will be important in making the design decisions.

Thermal Testing

We agree with the Board on the importance of thermal testing for reducing uncertainties in the thermal-hydrologic response of Yucca Mountain. We appreciate the Board's compliments on the progress in the thermal testing program.

We continue to value the Board's feedback as we pursue completion of the VA and the future work beyond. If you have any questions, please contact me at (202) 586-6842.

Sincerely,

A handwritten signature in black ink, appearing to read 'Lake H. Barrett', with a long horizontal flourish extending to the right.

Lake H. Barrett, Acting Director
Office of Civilian Radioactive
Waste Management



Department of Energy

Washington, DC 20585

September 8, 1998

SEP 09 1998

Dr. Jared L. Cohon
Chairman
Nuclear Waste Technical Review Board
2300 Clarendon Boulevard
Arlington, Virginia 22201-3367

Dear Dr. Cohon:

This letter transmits the Department of Energy's response to the Nuclear Waste Technical Review Board's *Report to the U.S. Congress and the Secretary of Energy: 1997 Findings and Recommendations*, issued in April 1998. Our response to the Board's recommendations are found in the enclosure.

As the Board noted, the Department has been focused on completing the viability assessment (VA) for a repository at Yucca Mountain, as directed by the President and Congress. The VA is a management tool for the Department and an important informational input to the policy process. Its completion this year will culminate a three-year effort by the Department to assemble the information collected during site characterization into a workable repository concept for Yucca Mountain and to focus the Program on the remaining key technical issues. Our plans call for a substantial effort after the VA to complete site characterization, to continue our design activities, and to develop and document the technical bases for a site recommendation and a license application, if the site is found suitable. As the Board has suggested, this effort will include the enhanced characterization of the repository block, long-term corrosion tests, and the drift-scale thermal test.

The Department appreciates the Board's constructive review and recommendations regarding the technical and scientific aspects of the Civilian Radioactive Waste Management Program. We continue to value the Board's feedback as we complete the VA and the additional work for a site recommendation. If you have any questions, please contact me at (202) 586-6842.

Sincerely,

A handwritten signature in black ink, appearing to read "Lake H. Barrett", written over a faint circular stamp.

Lake H. Barrett, Acting Director
Office of Civilian Radioactive
Waste Management

Enclosure



**Department of Energy's Response to the Recommendations
in the Nuclear Waste Technical Review Board's
Report to the U.S. Congress and the Secretary of Energy:
1997 Findings and Recommendations**

Recommendation 1:

The Board views the Department of Energy's (DOE) work on alternatives to the reference design as a vital element in the repository program. Although much of this work will be carried out subsequent to the viability assessment (VA), the DOE should consider including, in the VA, cost estimates of alternative repository design concept and sensitivity studies showing the effects of these alternative design concepts on long-term repository performance. Work on alternative repository designs should be started now, even if it cannot be included in the VA.

Response:

The Department is responding to the Board's interest in studies of alternative repository design concepts by establishing a working group to identify and evaluate major design alternatives. This effort ensures that an appropriately comprehensive evaluation of design features and alternative design concepts, including those suggested by the Board, are examined prior to selecting the reference design to support site recommendation and license application. The VA will describe the current status of the effort to evaluate design features and alternative design concepts. The VA will include sensitivity studies and costs only for a set of design enhancements for the VA reference design. The working group will address performance and cost issues for other major design alternatives after the VA.

As used in the VA, design feature refers to a component of a repository system, and alternative design concept refers to a layout developed specifically to incorporate particular design features. Certain design features are somewhat independent of the actual design layout; generally, they could be implemented in almost any layout. Other design features are more dependent on the design layout. Accordingly, to realize the performance enhancement potential of these design features, a specific layout must be considered.

The VA describes design features and alternative design concepts in sufficient detail to identify the studies needed to support selection of the reference design for site recommendation and license application. This future design could be closely related to the VA reference design or an enhanced version of that design. Also, it could be one of the VA alternative design concepts, or an as yet undeveloped design concept that takes advantage of the performance potential of one or more design features.

The goal of the evaluation is to provide an acceptable repository design for site recommendation and license application. This evaluation is an appropriate precursor to any submittal of a license application, as Nuclear Regulatory Commission (NRC) regulations require comparative evaluation of alternatives to major design features that are important to waste isolation. The

Department expects to interact with the Board during selection of the reference design in the event of site recommendation and license application to ensure that the Board's views are addressed.

Related to the Board's recommendation on alternative designs, the Board's report presented five questions related to the reference underground design, expressed concerns related to the waste package on galvanic protection and waste package fabrication, and suggested reconsideration of several concepts for surface operations. These issues are addressed below:

Underground Facilities Alternative Designs and Reference Designs

1. Why should the diameters of the emplacement drifts be 5.5 m?

Selection of the 5.5-m excavated emplacement drift diameter for the reference VA design resulted from the following major considerations. The drift diameter had to:

- accommodate the largest waste package dimension (approximately 2.0-m diameter) as well as the heaviest (154,000 lbs);
- provide an adequate operating envelope for a gantry (waste package carrier) to transport waste packages over the largest emplaced waste package, if necessary;
- provide for ground support systems up to 200-mm-thick and an invert. Even if no full circle lining were planned, any use of steel sets for occasional bad ground would require approximately the same clearance as that needed by the liner;
- meet the thermal goal of 200° C rock wall temperature and 350° C waste package core temperature with waste packages that have initial heat output as high as 18 kW.

Based on these considerations, a minimum of 5.1-m clear envelope was developed. Adding the 200-mm for lining, the excavated diameter is 5.5-m. Recent analysis indicates that the 5.5-m emplacement tunnel may not allow sufficient tolerances and operating envelopes. Providing the needed tolerances may cause a slight increase in diameters (~100 mm). However, the need to carry a waste package over another waste package will be reevaluated in a future analysis, which could change the requirements for drift size.

Since the existing diameter is required primarily by the gantry and largest waste package, any significant reduction in drift diameter could require a significant reduction in the largest waste package size and thermal output, a change in the emplacement mode, and elimination of backfill as an option. Alternate emplacement delivery systems such as railcars, which could allow a smaller diameter, may be employed and will be evaluated. Previous designs which used railcars indicated high costs and perceived difficulties with retrieval for that design.

The option of a small diameter emplacement drift is planned to be evaluated as a part of the design alternatives study. In that evaluation, the issues of drift stability, type of ground control system necessary, ease and cost of construction, compatibility with the waste package dimension

and weight, emplacement delivery systems, ventilation and other functional objectives will be evaluated.

2. *Has the potential effect of the exhaust drift underneath the repository on the long-term performance of the repository been evaluated?*

No detailed evaluations have been made of the potential thermal and thermomechanical effects on repository performance of the exhaust drift underneath the repository. The location of the exhaust main beneath the center of the emplacement area, and the slight slope of the emplacement drifts from the center down to the edges means that little or no water can drain from the emplacement drifts to the exhaust main. Thus, the exhaust main should not accumulate water from the emplacement drifts nor act as a fast path. While the non-thermally perturbed hydrologic effect of the exhaust shaft seems small, the thermal-hydrologic system has yet to be evaluated. The long term effects of an exhaust main beneath the repository level will be the subject of a future study.

3. *Is the value added by the exhaust drift worth its cost and potential effects, if any, on long-term performance?*

A central exhaust main is located below the emplacement drifts, midway between the east and west mains, and connects the mains located at the north and south ends of the repository block. The central exhaust main is used primarily for ventilation of the emplacement drifts and has the following values:

- It effectively reduces the total emplacement drift lengths by one-half, allowing emplacement operations from both east and west mains;
- It provides better logistics for emplacement operations to accommodate the thermal load management requirements, and improves the reliability of waste package transportation within the emplacement drifts by reducing the transportation distance to one-half of the total east-west drift length;
- It allows faster cool-down of any emplacement drifts, if re-entry is needed.

The Department considers that these values, which enhance the operation of the subsurface facilities, make the exhaust main worthwhile.

4. *Have the DOE's plans provided for the funds and time that will be needed to develop, demonstrate, and license the equipment, sensors, communication devices, etc., required for remote operations?*

The use of remotely controlled transportation and emplacement equipment significantly reduces worker exposure to radiation. It also reduces shielding needed to meet health and safety requirements. Remote systems are not planned to perform any drift maintenance. If such work is necessary, the drift will be cooled by ventilation, waste packages will be removed from the drift and placed in an empty drift, and work will be performed with personnel access in the drift.

The reference VA design utilizes remote systems that are based on proven technologies, not on technologies to be developed, and are expected to function safely and reliably under the anticipated radiation and thermal conditions in the repository operations area. However, because these technologies will be uniquely applied, designers are striving to keep the applications as simple as possible.

The Project's plans include a mock-up and testing program to demonstrate functions of the remote system. The remote equipment and the communications systems by which it is controlled will both be the subject of a significant test and evaluation program.

The evaluation of alternative designs will include at least one alternative in which the waste packages are emplaceable by on-board human operators and the emplacement drifts remain accessible throughout the pre-closure period.

5. *Why are the benefits of continuous ventilation of all drifts not being taken advantage of in the current design?*

Repository ventilation studies demonstrate that increased ventilation rates can remove both heat and water vapor from the emplacement drifts. However, there is not yet significant evidence to indicate that a strategy of aggressive continuous ventilation will lead to better long-term performance. The current Project strategy is to maintain high temperatures around the emplacement drifts in order to drive away water and keep the waste packages dry as long as possible. The upcoming design alternatives analysis, which will include performance assessments, will evaluate continuous ventilation at higher levels than currently shown in the reference design.

Galvanic Protection and Waste Package Fabrication

As suggested by the Board, the total system performance assessment (TSPA) for the VA does not take credit for galvanic protection. This is based mostly on the fact that the corrosion-allowance barrier (carbon steel) will degrade principally by general corrosion and not by localized corrosion. In this case, galvanic protection is less effective. The only concern, which is being addressed with ongoing testing, is the potential for high aspect ratio pitting corrosion of the carbon steel by high pH water that results from interaction of groundwater with high pH concrete utilized for the drift liner surrounding the waste package. In this case, galvanic protection may be significant because the throwing power of the galvanic current from the carbon steel would be able to cover the exposed area in the corrosion-resistant material at the base of the pit. Exposure of galvanic couples between carbon steel and corrosion-resistant materials as well as drip tests are underway. These tests should provide information on the nature of the attack and the throwing power of the carbon steel. The results would also indicate whether credit for galvanic protection can be taken for the license application.

On the Board's concern about integration between the performance assessment and engineering groups, the performance assessment staff are using a design baseline in completing TSPA-VA to ensure that the design assumptions for galvanic protection in performance assessment are

consistent with the engineering design assumptions for analyses addressing corrosion of the inner barrier. This formally controlled process is structured to avoid disconnects between engineering design and performance assessment.

The concerns expressed by the Board on residual stress from shrink-fitting of the two cylinders constituting the inner and outer waste package barriers are understood and are being investigated. Shrink-fitting is being considered for ensuring that the two cylinders do not move relative to each other, in addition to its potential benefit for providing some galvanic protection of the inner barrier. Shrink-fitting has been demonstrated to be a viable method of assembling two barriers in close mechanical contact. This has been proven by the fabrication of two mock-ups and is being used in industry routinely. It is at this time considered to be the easiest and most cost-effective method to achieve the required mechanical requirements. However, other methods will be evaluated before a final manufacturing method is selected. These evaluations will consider stresses, potential crevices, point loading from shifting centers of gravity, reliability of the fabrication and inspection processes, and cost.

The Board's concerns on the inspectability of final closure welds will be fully addressed before selecting the final fabrication and welding processes. The inspection by ultrasonic testing of the inner barrier on the Fiscal Year 1997 waste package mock-up was successfully accomplished. The inspectability of the inner weld by remote ultrasonic testing will be further investigated during Fiscal Year 1998.

Surface Facility Operations

The Board suggested that the Department reopen studies of multi-purpose canisters and other concepts where preparations at utilities could reduce handling of fuel assemblies and costs. The Department believes that the concept of multi-purpose canisters has merit. While the Department initiated the design and development of a multi-purpose canister system, the private sector has since embraced this activity. The Department does not plan to fund additional studies but will consider multi-purpose canister systems proposed by the private sector in response to our market-driven approach to transportation. The Department will also consider sharing any disposal cost savings from the use of a multi-purpose canister.

The Board also suggested that the Department reexamine the basis for the peak annual emplacement rate based on a concern that the waste handling facilities were being designed for a peak emplacement rate of 4,500 metric tons of uranium (MTU) that is significantly higher than the average rate of 3,300 MTU. The Department understands the concern that the waste handling facilities are cost drivers and the size of these facilities is sensitive to emplacement rate. The current design can annually process about 380 commercial spent nuclear fuel (SNF) waste packages (3000 MTU), 100 glass waste packages (250 MTU), and 70 DOE-owned SNF waste packages (50-150 MTU). This results in a peak annual emplacement rate of 3300-3450 MTU, which is comparable to the average rate of 3300 MTU and is a reasonable basis for design.

Recommendation 2:

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 group.

Response:

The Department recognizes the Board's concern regarding dose estimates to children. At this time, there are no U.S. Environmental Protection Agency (EPA), NRC, or Departmental radiation protection standards that specifically include children. Current regulatory practice is to estimate doses to a hypothetical representative adult, known as the Reference Man, using physiological parameters developed by the International Commission on Radiological Protection. The dose conversion factors estimated based on the Reference Man have uncertainties that are comparable in magnitude to the uncertainties in exposure assessments and to the estimates of cancer risks.

For purposes of radiation protection, the Department agrees with the EPA and the NRC that the assumptions exemplified by the Reference Man adequately characterize the general public, and a detailed consideration of factors, such as age and sex, is generally not necessary. As the Board is aware, estimating doses to children and other age-specific groups is a complex task because of factors such as systemic biokinetic models, gastrointestinal uptake factors, organ masses and positions, and food consumption habits, all of which change as a person ages.

The Department, however, will conduct a preliminary evaluation of the impact to children and other age groups and will report the results of that evaluation in a technical report, recognizing that the development of age-dependent dosimetric and biokinetics models is an ongoing international effort. The report will reflect currently available information, which may not fully address age-specific differences in some biokinetic parameters.

The concern about doses to children should be considered in light of the assumptions used in performance assessment for future populations. We assume, consistent with internationally accepted recommendations, that characteristics of the population tens of thousands of years in the future are similar to those of the current population, because we cannot reasonably forecast changes in characteristics of the population. This assumption has a large uncertainty and means that dose calculations indicate the range of likely performance of a repository for only a hypothetical population. As such, the doses should be viewed only as an indicator or figure of merit for repository performance. This indicator should be viewed in a different perspective from that for potential doses from currently operating facilities, where the characteristics of the population are known.

Recommendation 3:

The DOE should evaluate the need for site-specific data for supporting the biosphere modeling needed for license application, especially soil-to-plant transfer factors. The evaluation should

include an estimate of the length of time over which measurements of such parameters would be needed to produce a reliable data set. Plans for obtaining the necessary data should be developed now.

Response:

The Department appreciates the Board's conclusion that our approach to biosphere modeling seems appropriate and agrees that generic biosphere data will be adequate for many aspects of the modeling. The Department will continue to examine sources of uncertainty in the modeling, including the use of generic versus site-specific data. As recommended by the Board, an evaluation of using generic soil-to-plant transfer factors, or concentration ratios, has been initiated and is nearing completion.

This evaluation indicates that the values reported in the scientific literature for concentration ratios vary widely for several reasons. As the Board suggests, some of this variation is due to site-specific environmental conditions such as soil composition and texture. However, experimental procedures also contribute to the variation. For example, depth of sampling, sample preparation protocols (e.g., washing, cooking, and plant part versus whole plant analysis), pot versus garden experiments, plant species, and management practices (e.g., fertilizer, irrigation rates, and plowing) all influence experimental results. Therefore, the variation in reported values represents variations in both site-specific environmental conditions and experimental procedures.

The Department has been using generic concentration ratios published by the International Atomic Energy Agency (IAEA), because they were developed based on a critical review of existing scientific literature and data contributions from scientists generally using standardized experimental procedures. Although the use of generic concentration ratios does not appear to be the most important source of uncertainty in the biosphere modeling, the Department will continue its evaluation of generic versus site-specific concentration ratios for Amargosa Valley. In addition, we will continue to evaluate the applicability of the IAEA database to the Amargosa Valley, including the use of subsets of this database, which may be more relevant to the Amargosa Valley.

Recommendation 4:

The DOE should make full and effective use of the expert elicitations, both as direct input to performance assessment and design and for the technical insights provided. The DOE should provide a rationale for the way it intends to aggregate the views of different experts and how the individual views of the experts will be treated in performance assessment. The DOE should also consider developing guidelines on how the results of expert elicitations will be treated in light of new data.

Response:

The Department agrees with the Board on the value of expert elicitations. The application of the elicitations spans a range from direct use of aggregate Probability Distribution Functions to qualitative insights. For instance, the elicitations have provided direct inputs to TSPA by quantifying the range of infiltration rates applied to the surface of Yucca Mountain, the range of degradation rates of the corrosion-resistant inner waste package material C-22, and the range of effective dilution likely to occur in the saturated zone. In other cases, the elicitations have identified conceptual issues that have generally been addressed in sensitivity analyses, such as the range of conceptual models to describe unsaturated zone flow and transport, the range of alternative conceptual models used to determine the seepage into drifts, and the range of cladding degradation conceptual models. In cases where only one or two experts provided an assessment (e.g., microbiologically influenced corrosion), the elicitations usually required specialized knowledge, and the expert's opinion was only used for insight and/or input to sensitivity analyses. Yet another use of the expert elicitations has been to identify types of information that could be used to reduce the uncertainty in key components of TSPA.

The Department has developed quality assurance (QA) requirements and implementing procedures for the conduct of expert elicitations. These QA requirements and procedures for expert elicitations require documentation of the individual expert assessments and the process of aggregating their assessments, if the views of different experts are aggregated, and include guidelines for reevaluating the results of expert elicitations in the light of new data. For example, current Project plans include an activity for each fiscal year to identify new data that are relevant to the volcanic and seismic hazard analyses, such as the recent geodetic data across Yucca Mountain. The effect of these data on the results of the probabilistic volcanic and seismic hazard analyses will be evaluated if analyses, such as sensitivity studies, indicate that the effect may impact the hazard assessments.

The requirements and procedures reflect guidance provided by NRC in its *Branch Technical Position on the Use of Expert Elicitation in the High-level Radioactive Waste Program* (NUREG-1563). In meetings and correspondence, NRC has indicated that the Department's approach is in conformance with the NRC guidance and has closed numerous open items related to the Department's use of expert judgement.

Additional Board Comments

The Board's report raised issues beyond those captured in the four recommendations. Where these issues relate to topics in the recommendations, the Department's responses also address the related issues. Additional issues, concerning the environmental impact statement and transportation, are addressed below.

Environmental Impact Statement (EIS)

The Department welcomes the Board's interest in how the EIS will explore alternative designs and characterize the "no-action" alternative. The Department, as part of its ongoing design activities, is developing design alternatives for the repository and the engineered barrier system. We are preserving flexibility in the existing design approach to ensure that design alternatives now foreseen, as well as those that may emerge with advancements in technology, can be accommodated in the repository development process. We expect that design alternatives will continue to evolve and be evaluated throughout repository licensing, construction, and operation. Input from the Board, the NRC, and other interested parties will be important as design decisions are made.

We agree that the EIS process is an appropriate venue for exploring the potential environmental impacts of design features and alternatives. We believe that the ongoing design activities that will be discussed in the VA will represent a range of reasonable design alternatives, including those alternatives recommended by the Board for consideration. In the EIS, we intend to bound the environmental impacts for the full range of designs by analyzing the impacts from the EIS implementing design alternatives (i.e., three different thermal loads).

To ensure that the impacts from the range of designs are bounded by the thermal load implementing alternatives, a study is being conducted as input to the EIS. If significant environmental impacts are not bounded by the implementing alternatives, additional analysis will be performed. With this approach, we intend to provide sufficient analyses to encompass most design features and alternatives.

The Department recognizes the importance of characterizing the impacts from the "no-action" alternative and currently is considering how best to characterize the scope of the "no action", alternative. In making that decision, we will be mindful of the Nuclear Waste Policy Act's directive that the EIS need not consider alternative sites, the need for and time of availability of a repository, and alternatives to geologic disposal.

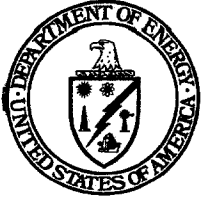
Transportation

The Department agrees with the Board that institutional issues related to transportation may require as much or more time to resolve as developing the physical infrastructure. The Office of Civilian Radioactive Waste Management works with other elements of the Department as they address such institutional issues as transportation planning, routing, emergency preparedness and training, and technical assistance for near-term radioactive materials shipments. The Department has been addressing these and other issues in preparation for the operation of the Waste Isolation Pilot Plant and for the foreign spent fuel shipments. These institutional issues have been recognized in our recent interactions with a broad range of stakeholders.

For example, we have issued core planning and policy statements for stakeholder comment. We issued a revised draft policy on April 30, 1998, for Safe Routine Transportation and Emergency Response Training, which defines policies for providing technical and financial assistance to States and Native American Tribes approximately four years prior to the start of shipping. The technical and financial assistance is a Department responsibility under Section 180c of the Nuclear Waste Policy Act. Our market-driven approach to transportation, for which the Department issued a revised draft Request for Proposals in November 1997, addresses the Department's and transportation regional service contractors' institutional responsibilities with regard to planning for emergency response, training, and public information. Institutional coordination with States and Tribes under the market-driven approach is intended to begin three to five years before the start of shipping. Our recent efforts related to Section 180c and the market-driven approach to transportation provide a working foundation for the Department to complete its transportation preparations and resolve remaining issues with affected stakeholders consistent with the planning basis for multi-year development and operation of the radioactive waste management system in 2010.

Concerning the need for full-scale testing of casks, the Department will continue to follow and comment on any related action by the relevant regulatory agencies. The use of dedicated trains, along with other rail safety and operations related issues, are being addressed through the Department's continuing dialog with the Association of American Railroads, the Federal Railroad Administration, and the rail industry for this Program, as well as through other Departmental transportation activities.

We are confident that transportation institutional issues will receive amplified attention and resolved once the decision regarding site recommendation has been made..



Department of Energy

Washington, DC 20585

October 19, 1998

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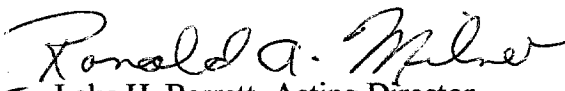
Dr. Jared L. Cohon
Chairman
Nuclear Waste Technical Review Board
2300 Clarendon Boulevard
Arlington, Virginia 22201-3367

Dear Dr. Cohon:

The Department of Energy has received and reviewed the Nuclear Waste Technical Review Board's letter of July 30, 1998, transmitting comments on its June 1998 meeting. We appreciate your compliments on the high level of technical content in the Department's presentations and on the coordination for the field trip. In an effort to address important issues in a timely manner, the Department would like to respond to the Board's comments. Our responses are provided in the attachment.

We continue to value the Board's feedback as we complete the viability assessment and work toward site recommendation. If you have any questions, please contact me at (202) 586-6842.

Sincerely,

for 
Lake H. Barrett, Acting Director
Office of Civilian Radioactive
Waste Management

Attachment



**Department of Energy Responses to the
July 30, 1998, Letter of the
Nuclear Waste Technical Review Board**

Total System Performance Assessment

The Department agrees with the Board that any set of calculations, including those presented on the status of the TSPA calculations for the VA, are only as valid as the underlying assumptions, models, and data. Time constraints at the June 1998 Board meeting did not permit a thorough presentation of the science underlying the calculations. More exhaustive presentations were made to the Board's Performance Assessment Panel in April 1998. The most complete documentation of the analyses is contained within Volume 3 (TSPA) of the VA and in the accompanying TSPA-VA Technical Basis Document.

The Board questioned how parameter uncertainties were assigned and whether parameters were appropriately correlated. The Department agrees that the parameter uncertainty analyses are dependent on the assigned uncertainty distributions. To address this concern, we also conducted a suite of sensitivity analyses, which provide additional insight into the range of possible behaviors. On the correlation question, the parameters cited in the Board's example, infiltration and seepage fraction, are fully correlated, and this correlation has been included in all analyses. Uncertainty analyses and correlations are presented in Volume 3 of the VA in summary level and in the TSPA-VA Technical Basis Document in detail. We recognize that additional uncertainty analyses and correlations will be required for the site recommendation and license application.

The TSPA team has consistently used comments made by the Board to improve the quality of our analyses. The Board's previous comments on making TSPA technically persuasive, transparent, and traceable, on paying proper attention to uncertainties, on coordinating with the repository safety strategy, on demonstrating validity with natural and engineering analogues, and on using simplified calculations, peer review, and outside expertise are all leading to improvements. We will continue to combine these suggestions with the comments we have received from the Nuclear Regulatory Commission (NRC) and the TSPA Peer Review Panel as we move forward to the TSPA for site recommendation and license application.

License Application Plan

We appreciate the Board's suggestion that the decision methodology be made more transparent and that the key measures of importance be defined more rigorously. The License Application Plan (Volume 4 of the VA) describes the additional technical work needed before the Department's decisions regarding site recommendation and license application can be made. That work includes evaluation of design alternatives and features that might enhance confidence in system performance. The Plan also identifies the work needed to address the remaining issues for postclosure performance and preclosure safety.

The Department's approach to determining the relative importance of the principal factors affecting these issues and the prioritization of the information needed to address them was outlined in the presentation to the Board. A more detailed description of the importance of the various principal factors and the prioritization of those factors are presented in Volume 4 of the VA. This discussion will provide additional information on work done subsequent to the June 1998 meeting that is responsive to the Board's comments on making the methodology more transparent and rigorous. However, uncertainties in characteristics of the system will continue to make the judgements about necessary work somewhat subjective. A completely rigorous assessment of the information needs in the face of these uncertainties is not practicable. Nevertheless, we hope the additional information provided in the VA will help illuminate the judgements that have been made.

Determination of Importance Evaluation on the East-West Crossing

The Board wrote that it "believes that the OCRWM has not addressed adequately mountain-scale coupled thermal, hydrologic and mechanical (THM) processes. The Board has not seen any rigorous THM analysis of whether the east-west crossing will affect long-term repository performance or will foreclose repository design alternatives."

Part of the Department's basis for excavating of the east-west cross-drift was our conclusion that the Determination of Importance Evaluation (DIE), Revision 2, adequately bounds the impact of the cross-drift on repository performance. This conclusion was based in part on these findings:

- An in-depth analysis of coupled thermal-hydraulic processes in the near-field environment demonstrates that the effects of the drift are small, even at the scale of the near-field model, and dampen out over time.
- Lateral gas-phase connectivity within the repository area would not change significantly due to the cross-drift, given the massive connections represented by waste emplacement drifts.
- The cross-drift may participate in thermal convection cells; however, this potential mechanism also exists in undisturbed rock due to natural fractures.
- Although the cross-drift effective conductivity is significantly larger than for fractures, any gas-phase process that connects the waste emplacement drifts with the cross-drift must also pass through fractured rock. Therefore, fracture conductivity will dominate the serially connected pathway.
- The cross-drift overlies only a very small number of waste packages; hence any adverse effects due to condensate drainage from the cross-drift onto waste packages would have a very limited effect.
- Operational controls (such as waste package selection to accommodate thermal mixing) will

preclude asymmetric thermal loads.

- Any flux (beyond the nominal fracture connectivity) that could occur between hot and cold drifts in a repository as a result of the presence of the cross-drift could be mitigated by backfilling the drift.
- There is no available technology to perform a rigorous mountain-scale coupled THM analysis. If such analysis is deemed necessary, the methodology could be developed and validated. Mountain-scale models currently in use do not yet take into account the effects of drifts; for example, ventilation models such as the one George Danko, University of Nevada - Reno, presented to the Board are based on drift-scale calculations. While the mountain-scale models do provide boundary and initial conditions for the near-field models (a "nested" approach), they do not provide sufficient resolution to assess the effects of the cross-drift.

The Department maintains that the practical, qualitative approach used for the mountain-scale analysis in the DIE is in accordance with standard geoenvironmental practice and conforms to the Department's DIE procedure. Standard practice performs appropriate analyses prior to design and construction, but is fully prepared to implement remedial measures, if necessary.

The possible effects on repository design alternatives were an important consideration in the decision where to site the cross-drift. A formal analysis was not included in the DIE, Rev. 2, as it was not required by the DIE procedure.

Revision 3 of the DIE was released on September 4, 1998. This revision includes consideration of expanded infiltration rates, operational controls to preclude asymmetric thermal loads, impacts of temporary storage of the Tunnel Boring Machine at Station 28+23 meters, expanded Quality Assurance controls, and several other features.

The Department has concluded that the DIE is technically adequate, based on available technology; however, we would appreciate your specific suggestions that would improve our THM processes. We look forward to further discussions with the Board on this matter.

Observations from the Field Trip

The Board complimented the Project for the rapid progress on the Busted Butte experiment and suggested examining related colloid transport work done at Hanford. In Fiscal Year 1999, we will collect and evaluate the field colloid information from Busted Butte and the Nevada Test Site. Additional laboratory information will be collected to determine forward and backward sorption/desorption rates based on drip test colloids.

The technical cross-fertilization now in progress with other sites will aid the Project in addressing issues of observed or projected radionuclide migration. The Department has opened a data and knowledge-sharing dialogue with the investigators responsible for characterizing and

understanding the migration of radionuclides observed at Hanford, the Idaho National Environmental and Engineering Laboratory, the Los Alamos National Laboratory, and the Nevada Test Site. Preliminary indications are that where migration of actinides has been observed, there was a direct link to the chemistry of the solutions involved, which were typically designed to keep actinides in solution or suspension. It is not appropriate to apply results from these sites directly to Yucca Mountain; however, anthropogenic analogue work will examine the colloid information at Hanford for potential use by the Project.

The Board also suggested that tunnels elsewhere on the Nevada Test Site (NTS) could provide information relevant to percolation during wetter climates at Yucca Mountain. The N-tunnel system was previously examined as part of a scoping exercise to select candidate sites for analogue studies. The tunnel is considered "wet" and has been sealed with a temporary bulkhead. Data are currently being collected for NTS through the bulkhead with remote monitoring equipment. A white paper was prepared several years ago that summarized what is known about the N-tunnel and further work was proposed; however, due to budget constraints the proposed work was not funded.

Environmental Impact Statement

The Board requested additional information on how the thermal load options bracket the environmental impacts from potential repository designs beyond what was presented during the June 24, 1998, meeting. The Department presented the logic for initially selecting a range of thermal loads as the underlying basis for the thermal load options to be evaluated in the Environmental Impact Statement (EIS). The intent of the EIS presentation was to put into context how the Project developed and is using the thermal load options. A report documenting the technical analyses and decisions on the range of potential repository designs is being prepared as an EIS reference, and we will provide you with the additional information.

Departmental staff and National Environmental Policy Act (NEPA) experts made the initial selection of thermal load options in informal planning sessions. That selection, in concert with the transportation options and spent nuclear fuel packaging options, was made in early to mid-1995 for purposes of developing the EIS Notice of Intent, which is the start of the NEPA process. Evaluating a range of thermal loads was considered to be reasonable for purposes of eliciting public input on the potential scope of the EIS during the scoping period for the EIS. This construct was believed to bound the potential environmental impacts of the design alternatives and features that were then being studied by the Project.

We are also conducting additional studies to ensure that the thermal load options adequately bound the environmental impacts of potential repository designs. This work is being conducted in close coordination with the reference design activities presented at the Board meeting. Because the environmental impact analysis is closely integrated with the analysis to determine the reference design to carry forward to site recommendation and license application, it will not be finalized until mid-1999. As the work proceeds, if environmental impacts are potentially not bounded by

the current EIS construct, additional analyses will be done and the draft EIS will be revised.

We look forward to sharing the results of our ongoing evaluations with the Board and specifically understanding what potentially significant types of environmental impacts that the Board thinks may not be bounded by the current construct of the EIS thermal load options.

Alternative Repository Designs

The Board was pleased with the Department's commitment to examine design alternatives before selecting a design for site recommendation and license application but questioned whether the examination would be as comprehensive as the Board desires. The scope of the Department's alternative repository design evaluations has been established with the goal of considering any repository design concepts that appear to have potential merit. Potential merit includes pre- and post-closure safety, operating and maintenance characteristics, cost, schedule, licensability, and risk considerations. The VA Reference Design and TSPA-VA will be used for evaluation purposes since there is substantial scientific and technical information available for them and they can be useful as a benchmark in comparing other design concepts. All concepts will receive an equitable consideration.

The Board also suggested that the Program examine relevant work done at the Basalt Waste Isolation Project (BWIP). The Program is taking advantage of experience such as BWIP in conducting its evaluations. Technical exchange visits to BWIP have been conducted. Technical documentation produced for BWIP and other programs is being captured during the compilation and evaluation of previous work that is relevant to our alternate designs and design features.

The work to evaluate alternative designs and design features is planned to be comprehensive and includes examples cited by the Board (i.e., restricted peak temperature, long term ventilation and waste package material layering options) as well as many others. Information on the budget for the alternatives work may not adequately reflect the extent of the effort. There is substantial work in the Fiscal Year 1999 planning, which will benefit the alternative effort although not coded as such (e.g., engineering on facility elements which are building blocks for alternatives). Also, substantial advantage will be taken of previous, well-documented work which has heretofore been presented as topical information, but which can now be applied in integrated design alternatives and design feature evaluations. Previous work will be updated as necessary.

The planning for the alternatives evaluation work has been geared towards meeting the May 1999 design decision. The schedule is challenging and has been identified as one of the top priority items by Project management, both in terms of management attention and support of resources to accomplish the work.