# UNITED STATES OF AMERICA
# NUCLEAR REGULATORY COMMISSION

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**UNITED STATES OF AMERICA**

**NUCLEAR REGULATORY COMMISSION**

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BRIEFING ON ACTIVITIES OF NUCLEAR
WASTE TECHNICAL REVIEW BOARD (NWTRB)

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PUBLIC MEETING

Nuclear Regulatory Commission
One White Flint North
Rockville, Maryland

Wednesday, March 3, 1993

The Commission met in open session, pursuant to notice, at 2:42 p.m., Ivan Selin, Chairman, presiding.

COMMISSIONERS PRESENT:

IVAN SELIN, Chairman of the Commission
KENNETH C. ROGERS, Commissioner
FORREST J. REMICK, Commissioner
JAMES R. CURTISS, Commissioner
E. GAIL de PLANQUE, Commissioner

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

SAMUEL J. CHILK, Secretary

WILLIAM C. PARLER, General Counsel

DOCTOR JOHN E. CANTLON, Chairman, Nuclear Waste Technical Review Board

DOCTOR D. WARNER NORTH, Nuclear Waste Technical Review Board

DOCTOR CLARENCE R. ALLEN, Nuclear Waste Technical Review Board

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

2:42 p.m.

CHAIRMAN SELIN: I think we'll have a full house in a minute, Doctor Cantlon, but we've kept you waiting long enough, so I'd prefer to start.

I'd like to greet you on behalf of the Nuclear Regulatory Commission. We're very pleased to have you here today. It's curious that the timing is such that your report, on which we look forward to an interesting summary, just hit the press yesterday with quite a bit of attention. I have to tell you, the issues that we saw reflected in the press are many of the same issues that have concerned the Commission. I'm sure you understand that we have a curious roll here because, on the one hand, much of what we do with respect to our regulatory functions to do with nuclear power reactors are based on a confidence finding that eventually there will be a repository for high-level waste and at the same time we are to license whatever repository the Department of Energy comes up with. We've set up all kinds of elaborate mechanisms and reporting to maintain the ability to do both of these functions at the same time.

But we've learned quite a bit and are very interested in what you have to tell us about the

reviews that you have undertaken. We are very anxious to learn from your perspective what the major issues are facing not only the management of the program but the Department of Energy. In some conversation beforehand you had some interesting insights as to even above the Department of Energy level, the questions facing the U.S. government in dealing with all aspects of high-level waste.

So, I think with that we're very pleased to welcome you here and turn the floor over to you, sir.

DOCTOR CANTLON: Thank you, Chairman Selin and members of the Commission. We're delighted to be here.

With me is Clarence Allen on my right and Warner North on my left. As we get to the question period, I will duck the questions that are outside my area of expertise. My field is environmental biology. Doctor Allen is a geologist/seismologist/geophysicist, and Doctor North is a risk assessment type. So, you're going to see me duck.

CHAIRMAN SELIN: You can see that the NRC staff is very curious about what a risk assessment type actually looks like. They've heard so much about this in the last couple years.

DOCTOR CANTLON: We also would make a -- besides commenting on the program of DOE, we, at the end, would make a comment or two on we think the interplay with NRC.

CHAIRMAN SELIN: Thank you. We'd appreciate your views.

DOCTOR CANTLON: (Slide) As you know, the Board was created by Congress in 1987 in the Nuclear Waste Policy Amendments Act and it's charged with evaluating the technical and scientific aspects of DOE's waste management program, including site characterization activities relating to the packaging and transportation of high-level radioactive waste and spent nuclear fuel. As you're also well aware, we're not part of the Department of Energy, but an independent agency.

(Slide) Members of our Board are nominated by the National Academy of Sciences and they are appointed by the President. I have served from the start of the Board and became its second chairman last year. We currently have ten of the authorized 11 members of the Board and I've listed those for you on the viewgraph. We all serve part-time.

The Board is organized into seven panels and they're shown on the next viewgraph.

(Slide) To provide you with some background on the Board, I'd like to outline briefly how the Board operates and then summarize some of the major recommendations that we've made to Congress and to the Secretary of Energy in our recent reports.

Our primary mode of operation has been to hold meetings of our full Board and of smaller Board panels. These meetings are open to the public. Participants include the DOE, its contractors, electric utilities, regulatory bodies, the State of Nevada and affected counties, and others who are involved in or concerned about the evolution of the U.S. radioactive waste management program.

We've also made a concerted effort to increase the Board members' knowledge of different approaches to the management of radioactive waste. To date, the Board as a whole has visited and met with the experts in spent fuel and high-level waste management in Canada, Finland, Germany, Sweden and Switzerland. The Board's Panel on Engineered Barrier Systems visited Japan last year and this year we plan to examine the programs in Belgium, France and the United Kingdom. We have learned a great deal from these interactions.

The Board is required to report to

Congress and the Secretary of Energy twice each year. So far the Board has published seven reports summarizing our activities and stating our conclusions and recommendations. The DOE has made a good faith effort to respond to much of this advice. Most of the recent reports -- the most recent report is this special report that some of you have already seen and it outlines several of the Board's major concerns.

The Board Chairman and staff also have participated a number of times in congressional committee hearings and have received and responded to written questions from congressional committees. We have also met with representatives of the Office of Management and Budget.

(Slide) During its four year review of the program, the Board has witnessed considerable progress, especially in site characterization and data collection at Yucca Mountain. And I think based on existing data, no scientific or technical basis has been established for rejecting the site. The Board believes that individuals working on the program, mostly scientists and engineers, are generally enthusiastic and very competent in their fields.

Following are some of the more important recommendations that we have made which we believe

will make the efforts more effective.

(Slide) First, the Board has been consistently concerned about determining the suitability of the Yucca Mountain site as soon as possible. If there are features at this site that could render it unsuitable, we need to find that out now. This will minimize unnecessary expenditure of funds on further characterization of the site.

(Slide) Our Board is convinced that underground exploration and the associated experiments at the repository level are crucial to the thorough evaluation of the suitability of the Yucca Mountain site for repository development. I might say as an aside here, we have not as a Board examined Nevada's recent claim that underground exploration may preclude adequate characterization of the gaseous pathways, but we will be looking at that.

The DOE needs to excavate the underground exploratory studies facility and to look at the faults at the level proposed for the repository, to look at the hydrogeology of the volcanic tuff host rock, to initiate the diverse testing essential to understanding radionuclide retention capabilities of the rock during and after the projected repository thermal conditions. We need to see what's down there

and to evaluate how it will behave if a repository is sited there.

The Board has recommended that the most effective and efficient way of conducting this underground exploration is through the use of tunnels excavated by means of mechanical boring machines. Present plans call for portal construction to take place this year; start-up of the tunnel boring machines by March of 1984 and completion of the exploratory studies facility by 1998.

We also have recommended that the DOE use a more cost effective small diameter tunnel which are all that's necessary really to evaluate site suitability and to conduct site characterization. Then if the site were to prove suitable, large diameter tunnels, if they are necessary, could be scaled up.

CHAIRMAN SELIN: Could you stop for a second?

DOCTOR CANTLON: Yes, I certainly will.

CHAIRMAN SELIN: Why do you believe people are looking at larger diameter tunnels now, or are planning? Is that to get a leg up on the actual construction or is it just an out of date conclusion?

DOCTOR CANTLON: Well, we had -- our Panel

on Geoengineering had a major exchange with the Department of Energy on this issue and the justification really falls into two categories. The first one, they made a presentation on enhanced ventilation in the tunnels. They also made a presentation of greater safety if you had broader tunnelways where you could have vehicles coming and going. I think we, after fairly lengthy exchange, felt that those issues could be resolved in other ways. The safety issue, for instance, by going to rail instead of two tracked highways up and down the tunnel.

So, I think there's a kind of compromise that has emerged and we feel that this issue pretty much now is behind us. DOE has settled in on a 25 foot, which is smaller than the 32 foot which was one end of the range that they were talking about, which we felt was really inappropriate.

There is no question but what DOE felt that having to expand the tunnels raised additional costs and potential problems. So, any aspect of the exploratory shaft construction that is congenial and compatible with a repository, of course, was attractive to them.

COMMISSIONER REMICK: And the reason for

the Board's consideration, would it be more timely? Would you be able to drill them more rapidly?

DOCTOR CANTLON: Faster, cheaper.

COMMISSIONER REMICK: Cheaper.

DOCTOR CANTLON: We want to get down and find out whether the site is a suitable site. So, looking at it from a narrow scientific and technical point, setting aside the reactor siting as a second level, next generation decision, let's get the first generation decision out of the way. Is the site capable of sustaining it? Then worry about building the repository.

DOCTOR NORTH: As one example, experts that we brought to the meeting suggested that the smaller tunnel boring machines might be more reliable. There would be less of a risk of a failure with one of these machines with, for example, a main bering that had to be replaced slowing down the effort.

DOCTOR CANTLON: Okay? A second --

COMMISSIONER ROGERS: Just on that.

DOCTOR CANTLON: Yes.

COMMISSIONER ROGERS: The question about standby or backup machines. How many machines do they expect to have, just one?

DOCTOR CANTLON: Just one is my

understanding.

COMMISSIONER ROGERS: And if that breaks down, they're out of business until they get it fixed.

DOCTOR ALLEN: Initially.

DOCTOR CANTLON: Yes, initially. And whether or not the second machine would be a mimic of the first or a shorter axis, better turning machine is another kind of question.

CHAIRMAN SELIN: Thank you, sir.

DOCTOR CANTLON: (Slide) The second issue that concerns the Board is the low priority the DOE has placed on studies of different types of engineered barriers. The DOE's 1988 base plan relies on the engineered barrier for radionuclide retention for only 300 to 1,000 years and proposes bore hole placement using thin walled non-self-shielded containers.

(Slide) The Board believes and has recommended that DOE place greater reliance on the engineered barrier system as a way to build redundant radionuclide retention into the repository design. This redundancy, in our view, should help reduce concern about repository safety, especially in the face of the inevitable uncertainties associated with predicting natural geologic, hydrologic and climatological processes far into the future.

The Board has tried to highlight the importance of engineered barriers, including the use of a robust long-lived waste package to the entire waste management system. Considering different engineered barrier design concepts, for example, means considering different repository designs, different options for waste emplacement and repository closure, and different containers as well as alternatives in packaging, storage and transportation components in the waste management system.

(Slide) With respect to designing the waste package itself, the Board believes that extensive materials testing is required. Of greatest importance, determining how various materials will hold up over long periods of time under the possible underground conditions of a repository is important. Despite this strong Board position, the DOE has chosen to accommodate its budget constraints by reducing funds going into the waste package development program. We believe it unwise to defer studies in this area.

The third issue is repository thermal loading. The choice of repository thermal loading has wide-ranging implications for the geology of the site, for the engineered barrier system and for the entire

radioactive waste management system. We found this issue so important that we held a three day conference on thermal loading in October of '91.

(Slide) As we see it, there are two basic approaches to thermal loading. The temperatures in the repository can either be kept below boiling or above the boiling point of water. Most countries are evaluating the potential of locating a repository at levels located below the water table. They assume that the repository temperature then will be kept below the boiling point of water for the lifetime of the repository.

(Slide) The DOE's 1988 base-line strategy at Yucca Mountain calls for a high initial temperature well above the boiling point of water for the first 300 to 1,000 years, with temperatures then falling below boiling. The theory behind the DOE's base-line strategy is that above boiling temperatures would drive away any liquid moisture that might otherwise make contact with the waste containers. This should prevent, or at least greatly retard, corrosion of the waste containers and the transport of radionuclides for at least 300 years. How the long-term geohydrology and radionuclide retention capabilities of the rock will actually perform under the higher

temperatures and the eventual temperature decrease has yet to be tested and evaluated.

An alternative long-term above boiling strategy was outlined briefly at the Board's '91 meeting. The theory behind the long-term above boiling strategy is that if it's good for waste isolation to keep the temperature above boiling for 300 to 1,000 years as in the base plan, keeping those temperatures above boiling for thousands of years may prove even better for long-term engineered barrier containment of radionuclides.

CHAIRMAN SELIN: I'm sorry. I don't have the background to follow that. Why is it good to keep the temperature higher for a longer time?

DOCTOR CANTLON: It keeps liquid water away from the container and in order for most corrosion to proceed or certainly to accelerate, the presence of water is --

DOCTOR NORTH: In liquid form.

DOCTOR CANTLON: Yes, in liquid form. So, if you have it above the boiling point of water, the water front, liquid water front is far away.

CHAIRMAN SELIN: Just boils off.

DOCTOR CANTLON: Yes.

CHAIRMAN SELIN: Okay.

DOCTOR CANTLON: This would allow for -- if you were able to keep this above the boiling point of water for literally thousands of years, well up to 10,000 years in some of the modeling, the opportunity for corrosion, you see, could be forestalled for that long, meaning that you could have container integrity.

COMMISSIONER ROGERS: Excuse me. Could I just ask a question?

DOCTOR CANTLON: Sure.

COMMISSIONER ROGERS: How long does it take for the temperature to build up just immediately after closure of the repository in either of these two models or these two propositions?

DOCTOR CANTLON: A few hundred years.

COMMISSIONER ROGERS: A few hundred years to build up to the boiling point? And that doesn't depend upon whether you're going for the long-term or the shorter term model?

DOCTOR NORTH: The rock doesn't conduct heat very well.

COMMISSIONER ROGERS: Yes.

DOCTOR NORTH: So, the heat essentially has nowhere to go. You gradually build it up in the rock and then the heat wave progresses out further away from the actual waste.

COMMISSIONER REMICK: I'm a little confused by the answer 200 years. I assumed that immediately next to the canister it would be much quicker. You must be talking about reaching a maximum before decreasing or something.

DOCTOR CANTLON: Well, he was talking about the general repository block. Obviously if you've put high temperatures next -- and recall, if you're going -- go ahead.

COMMISSIONER REMICK: Yes. You must be talking about it reaching some kind of an equilibrium or maximum before it decreases because, as I say, next to the canister it's going to be up to boiling very quickly, not 200 years certainly.

DOCTOR NORTH: You're right. It's a dynamic system and one has to analyze it as such. There have been models built to do this from Lawrence Livermore National Laboratory. At our meeting, the three day meeting that was described, we all became somewhat glassy eyed looking at what we were told were frog-eye plots, essentially expanding envelopes of different levels of temperature in the rock and depending on the loading that was chosen, you would watch those over a period of time, measured first in decades and then ultimately thousands of years.

COMMISSIONER REMICK: Has anybody looked at what the isotopic concentration would be to be able to sustain temperatures like that over 10,000 years? In other words, what the initial loading would be?

DOCTOR NORTH: Well, the basic issue is one of fuel aging. If the fuel is aged in interim storage, which could include air cooling in the repository itself with drift emplacement, then the short-lived radionuclides decay and so the heat load is much less. So, conceptually if one could age the fuel out the order of 50 to 100 years, then you have a heat loading per waste container that varies less rapidly than the short-lived.

DOCTOR CANTLON: Then you pack it in more densely to elevate it above.

The long-term heating impact on radionuclide retention, especially if future regulations extend beyond the 10,000 year period, then becomes an issue that clearly needs to be established with some good science.

(Slide) It is important to remember that the thermal strategy chosen will affect the entire waste management system. It will affect how much waste can be put into one repository, how the waste will be loaded into containers, how long the waste

must be aged prior to disposal, how the waste is packaged, handled, transported and emplaced in the repository, and how and when the drifts will be back-filled. Finally, it will affect how much the overall waste management program will cost.

(Slide) We believe that there are many uncertainties involved with each of the thermal loading strategies and these uncertainties and the hypotheses associated with them must be evaluated more thoroughly. Early initiation of long-term tests in heated rock in the repository is critical to the repository development program.

(Slide) Once the DOE has evaluated several strategies, their potential effects on the waste management system, a thermal loading strategy that best assures safe long-term waste isolation can be chosen. Much work still needs to be done.

(Slide) The fourth issues related to the fact that waste management, that is the transport, storage and disposal of spent fuel and high-level waste, should be viewed as an overall system whose separate elements and subelements can be highly interdependent. At best, the failure to adequately account for these interdependencies can lead to less than optimum configurations. At worst, it can lead to

errors that require costly and time confusing remediation. I previously mentioned the importance of choosing a thermal loading strategy for the repository and indicated its implication for all of the waste management system components. I would like to provide four additional illustrations of important system considerations.

(Slide) The DOE's base plan for the interim storage of radioactive spent fuel requires constructing a centralized interim storage facility in time to begin accepting spent fuel from the utilities by January 31st, 1998. However, on December 17th, 1992, in a letter to Senator Bennett Johnston, Chairman of the Senate Committee on Energy and Natural Resources, then Secretary of Energy Watkins acknowledged that no voluntary site for a central interim storage facility had been identified that would allow the DOE to meet the 1998 deadline. He asked Congress for interim storage of spent fuel at government sites. Considering initial reactions of some of the potential host states, this option may also prove difficult to implement. It therefore appears unlikely that any centralized interim storage facility will be available to begin accepting spent fuel from the utilities by 1998.

Apparently there are 25,000 metric tons of spent fuel stored at reactors around the country. This amount is being added to at a rate of about 2,000 metric tons per year. Under existing law, the capacity of a centralized facility is limited to only 10,000 metric tons before the repository operations begin. Even if a centralized storage facility with the current limit on capacity were constructed and a repository at Yucca Mountain were developed according to DOE's schedule, substantial amounts of spent fuel will probably remain in storage at reactor sites for decades. Yet the implications of extended interim spent fuel storage at whatever site have not been adequately addressed in the DOE's waste management total system planning.

The safety of the interim storage does not appear to be a serious technical problem. Your Commission, in the Waste Confidence Proceedings, has determined that spent fuel may be safely stored, wet or dry, for at least 100 years. However, some utilities have met with resistance when requesting permits from states and local authorities to use dry cask storage, due in large part to the lack of strong evidence that a repository will be available in the foreseeable future.

As discussed in the Board's Sixth Report, in other countries visited by the Board, the need for extended interim storage for all of the spent fuel is anticipated and was integrated into their waste management plans.

(Slide) A second example that illustrates these strong system interdependencies is the waste container. In the past, the DOE has considered separate containers for storage, transportation and disposal. This approach calls for reconfiguring the waste container as the function changes. Opportunities for human error, equipment failure and radiation exposure increase as the frequency of human handling increases.

Some nuclear facilities, faced with the prospect of long-term on-site storage, have investigated multipurpose container concepts that could be used to store, transport and perhaps even to dispose of spent fuel. The DOE is also increasing its efforts to develop a multipurpose container. Such a container would greatly reduce the risk of radiation exposure and obviate the need for routine hot cell transfers beyond the utility sites. Its consideration, however, requires a careful evaluation with respect to all of the other separate elements in

the overall waste management system.

(Slide) One topic that we believe is not --

CHAIRMAN SELIN: I'm sorry.

DOCTOR CANTLON: Yes. Yes.

CHAIRMAN SELIN: I wanted to wait until you were off the universal container.

DOCTOR CANTLON: Yes.

CHAIRMAN SELIN: We've identified some issues that would be raised from a licensing point of view in using a universal container for the repository. Have you seen any peculiar or really taxing issues from a scientific point of view?

DOCTOR CANTLON: Well, we don't have our engineered barrier specialist with us today. I don't recall --

DOCTOR NORTH: I don't recall that we have.

DOCTOR CANTLON: Nothing that I recall. Do you?

DOCTOR ALLEN: I don't think, no.

DOCTOR NORTH: I believe there's been some discussion with Doctor Bernero of your staff on this point and perhaps he might comment.

CHAIRMAN SELIN: I was curious if there

would seem anything unusual that had shown up in your deliberations.

DOCTOR CANTLON: No. There are a number of models, sort of an internal sleeve where you put the material in and then use different over packs and that sort of thing. So, we think that that is the way to go, but one needs now to take a look at the systems ramifications of those things and we think that's a weak spot.

CHAIRMAN SELIN: Fine. Thank you.

DOCTOR NORTH: Recall that our focus is on the technical issues rather than the licensing considerations. So, we may not be familiar with some of the issues that could possibly be important in the licensing of these casks.

CHAIRMAN SELIN: We're much more concerned that we're intimately familiar with the licensing issues, but that we not miss the science.

DOCTOR CANTLON: (Slide) One topic that we believe has not received sufficient attention is the fact that the repository will contain other waste forms aside from spent fuel. For example, the special problems posed by the disposal of high-level defense waste should be evaluated and integrated into the DOE's plan to manage all of the high-level radioactive

waste. Current estimates of the number of canisters that could come from defense facilities range from 15,000 to more than 200,000. This could result in a more complicated and difficult design process for the disposal system. Other high-level radioactive wastes such as the Three Mile Island 2 core, spent naval reactor fuel and other defense reactor spent fuel will also probably require disposal in a repository.

(Slide) Finally, we have to examine how long the spent fuel should remain retrievable after it has been placed in a repository. The 1988 base plan design calls for the Yucca Mountain repository to meet the 50 year NRC retrieval requirement. However, there may be advantages to a much longer retrieval period such as being able to monitor waste package performance or to recover spent fuel for economic or other reasons. There also are disadvantages such as the costs associated with monitoring and maintaining the repository after it has reached capacity. The pros and cons associated with various retrievability options should be analyzed more thoroughly now before decisions are made that could limit the system's long-term retrievability option.

CHAIRMAN SELIN: Other than the possible economic value of the spent fuel itself and this

question of monitoring, are there any other scientific benefits that you see to a longer period of retrievability?

DOCTOR CANTLON: Well, primarily there is so much anxiety in terms of container life and so on that we do think there'd be some merit in getting an opportunity to get down. Now, one doesn't necessarily need continuous monitoring. One could just enter it periodically.

DOCTOR ALLEN: It would give you a longer opportunity to observe possible failures of any of the canisters and to retrieve them for that reason if necessary.

DOCTOR NORTH: There's also the opportunity to get more information through essentially extended data on the effect of heating. So, if, for example, predictions that were made on the basis of a ten year heater experiment prove to be faulty after 25 years of waste in place, it might be possible to adjust the spacing or to take other corrective action perhaps in the design of the backfill material or other aspects of the engineered barrier. Some of this might involve retrieval. Some of it might involve changing the spacing.

DOCTOR ALLEN: Yes. Doctor Barnard has

also pointed out that with additional time and cooling the canisters, it might be possible to add more material to give greater capacity to the overall site.

COMMISSIONER de PLANQUE: Could I ask you what kind of time intervals are other countries considering on the retrievability issue?

DOCTOR NORTH: We're not aware that other countries have determined what they are going to do in that way in the same fashion as in the United States. Fifty years has been chosen as the baseline. I think rather they are considering that they will learn more as they go through their program planning and they will select a period at a later time.

DOCTOR CANTLON: Yes. Numbers 25 to 100 years are the kinds of things --

COMMISSIONER de PLANQUE: Yes.

DOCTOR ALLEN: Also, most other countries are going below the water table, which complicates the problems of retrievability. One advantage we perhaps have if the present site proves suitable is it is above the water table.

COMMISSIONER REMICK: Has the Board taken any position on the pros and cons from a scientific standpoint putting spent fuel in the repository versus in an above ground MRS for an extended period of time?

DOCTOR CANTLON: The short answer is the Board hasn't addressed that as a Board. We've obviously got individual views on that. I'll state mine. I think if one looks at the recent happening in New York, the vulnerability of above ground storage can't be as safe as putting things down. It's very difficult to hide a drill rig or any other device for getting down and getting into it or the behavior of fuels stored that far underground. It's very difficult to visualize a situation in which you'd create a great problem. But above ground storage is very difficult to, I think, handle the terrace problem.

DOCTOR NORTH: Well, we have asked the question in our tour at Surry, "What would happen if a terrorist had immediate access to the outside of this container with an armor piercing round? Would this create a terrific problem for public exposure?" And we were told no, the answer was the shell would penetrate but it would be very difficult to create a substantial release of radioactive material, especially a release that would go outside of the immediate site area.

DOCTOR ALLEN: But I shudder to think over the next 100 years what kinds of weapons and weapon

delivery systems might be developed and in the hands of potential troublemakers.

DOCTOR CANTLON: (Slide) Well, the Board believes that the DOE should place a very high priority on developing a comprehensive, well integrated systems oriented plan for the overall management of all of the spent fuel and high-level waste from generation to disposal. This plan, to emerge iteratively, should be based on a systematic assessment of options related to storage, transport and disposal of spent fuel and high-level waste.

(Slide) A fifth issue has to do with the management of the radioactive waste program. The civilian radioactive waste program encompasses work undertaken by the DOE, its dozen or so private contractors, a number of national laboratories, the U.S. Geological Survey, as well as many others. The number of people now working on the program totals almost 2,000, roughly 200 DOE employees and 1750 contractor employees. The program's organizational structure is multilayered and the entities are geographically dispersed. Responsibility is shared among these entities and seems to be diffuse.

(Slide) This large and unwieldy organizational structure also creates substantial

integration problems. Although a management and operations contractor was hired in 1990 to consolidate and integrate program activities, the DOE doesn't seem to be using the management and operations contractor in the normal way. Integration remains a major problem that contributes to inefficiencies in the program, especially in the development of a well integrated waste management plan. The lack of such a plan affects all aspects of the technical and scientific program.

Another Board concern in the area of management is the funding allocation decisions. For example, in fiscal year 1993, funding for overhead and infrastructure, according to the DOE the basic costs necessary to keep the program operating, will account for approximately 56 percent of the total funds for site characterization. Allocating such a high portion of funds to overhead and infrastructure leaves limited funding for important testing and research and may have already contributed to delays in the initiation of the underground excavation and in the development of a long-lived waste package.

(Slide) Other countries visited by the Board provide interesting alternatives to the U.S. program's organizational approach. For example, in

some countries a government-sponsored corporation or organization has been created to implement radioactive waste management programs. In addition, most of the countries the Board visited, nuclear waste producers are responsible for safely managing their nuclear wastes, including in most cases planning, financing and executing all research, interim storage, transportation and disposal activities. There seems to be more financial and managerial accountability in these countries and their programs appear to be more effectively managed than in the United States.

Alternatives to the current U.S. organizational and management approach were evaluated in two congressionally mandated studies in the mid-'80s. Since then, no detailed comparison of the U.S. approach with alternative management approaches has been undertaken. However, we understand that Secretary O'Leary at her confirmation hearing in January indicated that she may undertake a review of the civilian radioactive waste management program.

(Slide) The Board believes that the effectiveness of program management and integration needs to be improved and that the program would benefit from a thorough independent review of its organizational structure. Taking a look at the

approaches used in other countries could be one useful element in such a review.

(Slide) The final Board recommendation I would like to discuss today is what we believe to be the negative effect of unrealistic deadlines. The 1982 Nuclear Waste Policy Act authorized the DOE to enter into contracts with the utilities for the acceptance, transport and disposal of their spent fuel. According to the Act, federal acceptance of spent fuel for disposal in the repository was to begin by January 31st, 1998. I might add that the U.S. program is the only one that we know of that has been given a legislatively mandated date to begin disposal or spent nuclear fuel.

CHAIRMAN SELIN: Is it also the only program that foresees the progress in the final repository before much progress can be made in the intermediate repository?

DOCTOR CANTLON: Yes. Yes. Almost all of those have an interim storage built into their management plan.

In January 1987, realizing that this deadline could not be met, DOE changed the planned start-up date for the repository to 2003, only to change it again two years later to 2010.

The original 1998 date for repository operations slipped because it was not based on a realistic assessment of the technical requirements of the program. According to the DOE, to meet the 2010 goal, it will be necessary to submit an application to your Commission by 2001 for authorization to construct the repository. Before filing an application for construction, DOE must first make a determination of whether or not the site at Yucca Mountain is suitable for repository development. However, the Board is concerned that there may not be enough time to complete the critical technical activities necessary to make the decisions to meet these dates.

(Slide) For example, the planned long-term heater experiments, vital to determining the validity of the assumptions underlying the choice of a thermal loading strategy are not scheduled to begin until 1996 and may require a decade or even more possibly to complete. There also may not be enough time at present funding levels to adequately evaluate the long-term behavior of materials, under repository conditions, and information that is needed for waste package design.

A number of other factors that are beyond DOE's control could contribute significantly to

further delays in program progress and affect the current schedule. For example, to meet the 2001 deadline the DOE has said that it would need an average of approximately $600 million a year for the next seven years just for site characterization activities. The DOE has never submitted a request to Congress for funding at anything approaching this level.

CHAIRMAN SELIN: Can I stop you for a second?

DOCTOR CANTLON: Sure.

CHAIRMAN SELIN: It's quite obvious from a project management and construction and funding point of view that there are real problems there, but a little more subtle are the questions of are there scientific questions. Just the elapsed time that's going to be needed would make it impossible to meet these tasks even if the resources were made available on a --

DOCTOR CANTLON: That's the central of my earlier statement. We think the thermal studies -- now, there is a proposal that one can speed up the thermal studies by driving them with higher temperatures, but that's sort of like baking a cake at 500 degrees for ten minutes instead of 250 or 300

degrees for --

CHAIRMAN SELIN: You're a lot more graphic than --

DOCTOR CANTLON: Yes. The physics of handling crystallography and water crystallization and all of those things are very temperature-sensitive issues and we think, if you're going to keep the technical and scientific community in an open kind of way, you don't do it that way.

CHAIRMAN SELIN: Just to follow up, I did notice when you said that -- the first thing I was asking, was there anything other than the thermal questions?

DOCTOR CANTLON: Yes. The waste package behavior in terms of its chemical interaction with the surrounding in the site also takes in the order of a decade, according to the material scientists who are doing that kind of work, so there are at least two technical things that we think really require more time.

DOCTOR NORTH: I might add to that. Our problem is with the lack of planning.

CHAIRMAN SELIN: Right.

DOCTOR NORTH: Much of what we have just told you on these issues is developed not from formal

planning documents. They don't exist. It's been developed by our conversations with individual researchers.

CHAIRMAN SELIN: Okay.

DOCTOR NORTH: So our concern is not that ten years is the right number for the test and they're only allowing five, but rather we haven't seen a study plan, nor have you, for the thermal testing that we believe is necessary in order to support the decisions on repository design.

CHAIRMAN SELIN: You have not exhausted the list of topics on which we have not seen a study plan.

But the next question I was going to ask you is, would it be possible to do a Gedankin design where you sort of sit down and say -- let's assume a reasonable level of funding. I mean, in other words, not something crazy, but where you don't have really terrible funding constraints. If you took that from a scientific point of view, what do you have to learn in order to make these decisions and what's the right time to take, and then worked back and looked at the financing, what --

DOCTOR NORTH: Yes, that's exactly what we would like to see. We started asking questions. Why

was the assumption made of a thermal loading of 57 kilowatts per acre? What is the reason, the thinking process that lies behind that loading level? And we were dissatisfied with what we obtained.

CHAIRMAN SELIN: But that's not within your charter or capability to try to do. It's to point out --

DOCTOR NORTH: No. We can only criticize that we believe that it has not been adequately done and we have strongly encouraged the Department of Energy to carry out these planning studies and present a technical basis for the critical decisions on the program.

CHAIRMAN SELIN: To the point of looking at a technically driven schedule as opposed to a cost and budget driven schedule?

DOCTOR NORTH: Yes, so that we can see clearly what the technical basis for the schedule is and identify where the timing of scientific experiments becomes the critical issue in the program schedule.

CHAIRMAN SELIN: But have you gone the next step and said, "Take a look at the rate at which it is possible to uncover some of these informations and see what kind of dates we're talking about"? I

hear you saying that you want to make sure that people look at the technical implications of different schedules, but have you gone to the point of changing the dependent and independent variables to, say, drive it from a how long it takes these processes to develop point of view and then see what kind of a program comes out?

DOCTOR NORTH: We have opinions as to what the effect might be, but we haven't done analyses of our own to try to determine these on I'll say a firmer basis.

DOCTOR CANTLON: And we're not really staffed up for that.

DOCTOR NORTH: For example, the heater issue. We think the additional time may be of the order of perhaps five to ten years as opposed to six months.

CHAIRMAN SELIN: Commissioner Remick?

COMMISSIONER REMICK: If I recall, somewhere in the last decade there were some heated tests run out there. I don't remember if it was --

DOCTOR NORTH: That's correct, in G-tunnel.

COMMISSIONER REMICK: Yes, that's right. I assume that was not to answer the geological and

hydrological questions, but I forget what the purpose was.

DOCTOR NORTH: Well, those tests would have been very useful had they been continued, but the Defense Nuclear Agency no longer was going to pay for the maintenance of the G-tunnel facility and the Department of Energy decided that they would not pick up that additional cost and the whole facility closed down. Now, in retrospect that seems like a very poor decision if, indeed, the heater experiment was the long lead time item. It might have been well worthwhile to have kept G-tunnel open and continued those tests, but at that time the Department of Energy had not really investigated the alternatives for thermal loading. They simply had an assumption in their 1989 plan and so that insight wasn't obtained until after the critical decision had been made.

DOCTOR CANTLON: I think there's something to say in terms of maybe elements in the technical community, but perhaps more generally the general public, of having the experiments in the repository level, that you're dealing with precisely the site and what you say about it now is relevant to what it is you're going to do.

COMMISSIONER REMICK: Was G-tunnel tuffs

material? I forget.

DOCTOR NORTH: Yes, but there's considerable difference between the different strata of tuff.

DOCTOR ALLEN: They were all valid questions. If the rock is not the same in the exact unit that's --

CHAIRMAN SELIN: What did you just say? I mean, are you suggesting that radioactive heat sources be used in the --

DOCTOR CANTLON: No, no. No, no. I'm saying that the site in which the heater experiments are conducted, there's a certain degree of comfort if the data you get from those experiments is relevant to the site where you're going to put the fuel.

CHAIRMAN SELIN: But not to the point of emplacing radioactive --

DOCTOR CANTLON: No. That's a different issue and we know it is a very live issue. Our approach on that question is we'd like to see the scientific and technically justified reason for using spent fuel as a heating source as opposed to an electrical source.

CHAIRMAN SELIN: I see.

DOCTOR ALLEN: If there is such an

argument.

DOCTOR CANTLON: Yes. You know, there may be and we haven't seen that yet, but it's conceivable. They have some rationale for that approach.

DOCTOR NORTH: I think to get to the question that Commissioner Remick was asking, there are significant differences in the degree of fracturing and the mineral content of the different tuff layers and therefore what is found in an experiment in G-tunnel in slightly different tuff miles away may differ from what would be found at the repository horizon in the proposed site.

DOCTOR ALLEN: It's very clear that, if you've seen one tuff, you haven't seen them all. They are very different, very different.

COMMISSIONER REMICK: I assume that applies-- I know there's been extensive experimental work by the University of Arizona also on some tuffs. I assume the same thing applies there?

DOCTOR ALLEN: Yes.

DOCTOR CANTLON: Well, another factor, I think, to think about in terms of schedules and timing and the fact that we think the schedules are overly optimistic is the Energy Policy Act of 1992 in which the regulatory basis is called upon for reexamination.

The time course of that examination of the regulatory basis is a minimum of two and probably more realistically in the three or so years of time, and so we think that needs also to be incorporated in as one looks at the planning schedule.

Also, in the Board's view, there just isn't any room in the current schedule to accommodate unforeseen technical uncertainties or institutional problems that are inevitably emerging during unpopular first of a kind projects.

(Slide) Well, considering past delays and the potential for future delays, the Board seriously doubts that either the 2001 deadline for construction authorization or the 2010 repository development deadline can be met. The Board's concern rests on the fact that attempting to meet the current unrealistic deadlines might force the DOE to make decisions about important technical aspects of the program without first performing adequate and appropriate technical and scientific analyses.

COMMISSIONER CURTISS: Just a question here.

DOCTOR CANTLON: Yes?

COMMISSIONER CURTISS: I don't read what you just told us or your report as suggesting you

don't think deadlines ought to be established.

DOCTOR CANTLON: Oh, no, no.

COMMISSIONER CURTISS: You think the existing deadline of 1998 and 2010 is unrealistic, given the conversations that you've had with folks about what testing needs to be done.

As I read what you're proposing in your report just released here this week, what you propose that DOE do is to take a good hard look at what needs to be done between now and then, establish some interim goals as you describe them in this report which are intermediate milestones towards achieving and ultimate objective of emplacement of waste in the facility.

I'm endeavoring to elicit from you an answer that I may not get. Do you have a sense as to what those intermediate goals would add up to in terms of what the long-term objective of a date for waste emplacement would look like or does it depend on what DOE comes up with?

DOCTOR CANTLON: We have not engaged in that particular exercise. What we've said is we recognize that Congress and the Agency itself in dealing with contractors needs accountability structure of some type, therefore you set milestones

and goals for specific things.

We think that setting the sort of final milestone is the most difficult one. It's much easier to set up interim goals. For instance, setting a date to get underground, setting a date to get the heater experiments underway, setting a date to get the materials study for the containers in place, these are very explicit achievable things where you can get good hard numbers and set those out. Now, out of that exercise the thing that you're asking whether we've done could emerge. We have not done it.

COMMISSIONER CURTISS: The deadlines that were established -- and I'm familiar with a couple of them -- in 1982, 1998 looked like a pretty reasonable deadline to those in Congress who established it. And I suspect in 1987, 2003 or 2010 looked like a pretty reasonable deadline. Your point here is that they really haven't sat down and done a disciplined analysis of the intermediate steps that need to be undertaken, getting underground, doing the testing, identifying how long that testing will require, as intermediate milestones prior to achieving that ultimate objective.

DOCTOR CANTLON: I guess, in DOE's defense, one would have to say that this is a first of

a kind operation. There is no similar thing that's been done, completed in the world. There's no precedent for this kind of an operation.

Now, a thing as routine and straightforward as a reactor, if one looks at the projected schedules of building and siting a number of reactors, you had what turned out to be very unrealistic schedules in terms of bringing those on. And everybody says those were essentially organizational or political things. Well, obviously they complicated it, but there were many technical details that emerged out of just understanding new technology and, you know, this is the newest technology in the world in a sense, putting the total thing together.

COMMISSIONER CURTISS: I didn't want to incorrectly infer from your observation about what other countries are doing and the fact that there aren't any schedules that have been established in other countries for specific dates to suggest that what we ought to do in this country is to move away entirely from schedules. The observation has been made in the context of the MRS and the voluntary siting effort that schedules are the real problem. Deadlines are a problem in this business and I don't

share that view and I don't hear you saying here that you ought not to have any schedules at all but ought to have realistic schedules after evaluating what's required to be done between now and when we achieve the ultimate objective.

DOCTOR CANTLON: Right. And again, borrowing from the other countries, they are talking in the ball park of 2020 as opposed to 2010. But these are soft statements about those goals. They recognize that as they get closer and closer to the point at which they're going to be setting up a site, they're going to need to know more and more in detail about the technical and scientific underpinnings of that site. So, they're more or less relaxed about whether they precisely meet 2020 or not. That's, I think, the thing that we have to learn in addressing this kind of a study.

COMMISSIONER CURTISS: Yes. I raised the question because in the context of our responsibilities and specifically in the context of waste confidence, schedules do make a difference for us. Not the difference between 1998 and 2003 necessarily, but at some point we're under an obligation to determine that waste can be safely disposed of.

DOCTOR CANTLON: Yes, understood.

Well, there are many advantages associated with establishing a new, more flexible long-term schedule that incorporates firm target dates for interim goals, such as getting underground, determining site suitability and completing essential testing. Decisions made under pressure can lead to mistakes and costly remediation or potential licensing problems that may, in fact, extend the date. Adopting a more realistic schedule may actually speed the program progress and improve the system's cost effectiveness over the long run.

I'd like to conclude my presentation today with some comments that the Board has with respect to NRC's role in the current process. In addition to personal contacts and to reading the NRC staff positions on technical issues, the Board has heard the NRC's viewpoint at Board meetings, at DOE and NRC technical exchanges, and at the very informative meetings of the Advisory Committee on Nuclear Waste. We are impressed by the quality and the openness of these interactions and wish to express the Board's thanks for these opportunities.

CHAIRMAN SELIN: Which interactions are these, Doctor Cantlon?

DOCTOR CANTLON: Interactions with the Advisory Committee on Nuclear Waste, the DOE and the NRC interchanges and they've, of course, participated in a number of our sessions as well.

(Slide) There are several issues that we would like to suggest you look at. First is the issue of the regulations. We, in our previous reports, as well as the National Academy of Sciences in its 1990 report on "Rethinking High-Level Radioactive Waste Disposal," have touched upon problems associated with the technical aspects of the standards and regulations used in determining site suitability and repository construction and licensing. The Board noted from its trips abroad that those countries that we visited, the regulations used with respect to the disposal of spent fuel and high-level waste are less prescriptive than the U.S. regulations. All these countries currently have a more flexible approach than the United States and this allows considerable flexibility in the application of best available technologies to the waste disposal problem.

As a -- yes?

CHAIRMAN SELIN: Could you be a little more explicit as to what you might see our regulations look like?

DOCTOR CANTLON: Well, I think really what we -- this best available technology approach. For instance, I think that if you look at the interplay between the engineered barrier and the natural barrier, you've got relatively rigid constraints on the latter particularly. At the time, I suppose, driving that system was the DOE's base plan, which had a thin walled container and so on. But if one adopts the idea that a much more robust engineered barrier along the lines that many of the foreign countries are considering, the best available technology, in one sense the regulation constrains utilizing or appears to constrain. Now, I know there's been an argument that DOE would have the option of petitioning for easement on the geologic barrier, but again it's a constraint of the regulations on using best available technology.

A similar one would have to deal with the whole area of the water, movement of underground water, which again is one of the regulatory qualifications. If you design a repository at the high thermal load, then you can actually slow up the release of these materials and the movement of water, the rate at which underground water moves then is less relevant and one could go even further and say that

the rate at which water moves underground is only one of the dimensions of radionuclide mobility which has to do with adsorption and all of the other geochemical characteristics. So, we think that in being very precise on detailed parts of the regulations, you have in a sense constrained the opportunity to address it as a gestalt.

CHAIRMAN SELIN: Be exactly wrong instead of roughly right. You'd like to see us go more towards regulations --

DOCTOR CANTLON: Risk-related --

CHAIRMAN SELIN: Risk-related or transport rate-related without saying how it's achieved.

DOCTOR CANTLON: Yes.

CHAIRMAN SELIN: Well, how about the risk-related as opposed to dose-related? Have you looked at that? Just to choose a topic.

DOCTOR CANTLON: Well, just to choose it. Well, and as I told you at the beginning, one vacancy on our Board is our health physicist.

CHAIRMAN SELIN: By design?

DOCTOR CANTLON: No, not by design. Definitely not by design. We have been waiting two years to get that position refilled. I don't think it would be useful for us to try to make any constructive

comment on that area.

So, as we previously stated then, we believe that increasing emphasis on engineered barriers using long-lived containers can only enhance the scientific and technical confidence in long-term ability of a repository to contain and isolate harmful radionuclides. However, it's not always possible to view engineered and natural barriers as completely independent systems. Indeed, tradeoffs can be made. A preferred objective would seem to be to design a system of natural and engineered barriers that together provide increased and more certain long-term protection to the public. A natural hazard that can be easily remedied by good engineering should be viewed in a different light from one that is not easily remedied.

The ACNW, in its letter of December 1, 1992, raised a similar concern. We support their view that the Commission may wish to examine NRC positions that unnecessarily limit the role of engineered barriers are allowed to play, so as to "ensure that the DOE is not burdened with a requirement that is neither necessary nor feasible to implement and continues to provide little assurance of protection for the health and safety of the public." That's a

quote.

Third is the issue of expert judgment. There is little doubt that even the most extensive data gathering program will not eliminate the need for the use of expert judgment in reaching conclusions on many contentious issues in this regard. This has been the experience in siting and construction of many critical facilities throughout the world. Because of the unique requirement to provide reasonable assurance that a repository will perform adequately for many thousands of years, the use of expert judgment in a licensing board hearing may be particularly important.

We've observed that the NRC staff and the DOE do not necessarily agree on how expert judgments should be used. We would urge that the Commission initiate a process by which its staff and the DOE can come to some early agreement on the use of expert judgment before licensing hearings begin. The focus of these critical hearings should be on the judgments themselves rather than on the methodology for arriving at those judgments.

Finally, I'd like to address the issue of setting priorities. The Board has made a point in its interactions with the DOE of emphasizing the need to set priorities in their investigations. This is to

give prime emphasis to those studies that will allow the early determination of the site suitability and the resolution of the key technical issues. It's our believe that the more than 100 study plans based on the 1988 site characterization plan are not of equal value with respect to assuring a safe repository.

The Commission may wish to pursue a similar process in looking at it. It could be useful for the DOE to know your view as to what you believe really counts. This could help the DOE to better focus its energies. We note that the NRC staff has embarked on a program of iterative performance assessment. The staff presented their initial results to the Board and we believe that such a program could be very useful in assisting in this matter of examining priorities.

In summary then, I'd like to restate several points. First, the Board, based on existing data, feel that there is no scientific or technical basis for rejecting the Yucca Mountain site as a potential location for a high-level waste repository.

Second, much work is needed to address some of the critical, technical and scientific issues. I mentioned the need for early determination of site suitability, the importance of engineered barriers,

the critical role played by repository thermal loading, and the need to look at waste management, that is storage, transportation, and disposal as an integrated, interdependent system.

Third, nontechnical issues such as organizational and schedule can, and we believe, adversely affect the program's terminal activities. We believe that the DOE needs an independent look at its organizational structure and that realistic schedules that emphasize interim goals need to be established. However, such reviews of DOE's activities should not impede the accelerating program to examine the repository horizon and initiate long-term experiments in the exploratory studies facility.

Finally I touched on the Board's views with respect to NRC's role and made some suggestions that the Commission may wish to consider. I mentioned regulations, the need to take a look at other roles for the engineered and natural barriers, the importance of coming to agreement on employment of expert judgment, and the need for further guidance from NRC on what constitutes the more important technical and scientific issues.

Thank you very much for inviting us and we enjoyed the opportunity.

CHAIRMAN SELIN: Well, we certainly look forward to that. But don't think we've exhausted the questions yet.

DOCTOR CANTLON: No, no.

CHAIRMAN SELIN: Commissioner Rogers?

COMMISSIONER ROGERS: Yes. Your focus or emphasis on the total system, storage transportation disposal aspects and their overlapping characteristics, to what extent do you think that all three of those have to be taken into account in actually evaluating the suitability of the site itself, a site itself?

DOCTOR CANTLON: I'm going to refer that to our risk man.

DOCTOR NORTH: Well, clearly the issue of evaluating the site itself as suitable is more easily decoupled than the questions having to do with the acceptability of a particular repository design at that site. We have repeatedly urged that DOE place a very high priority on those activities that would support early determination of site suitability. Nonetheless, a lot of the scientific investigations support both objectives, both characterizing the site for suitability and learning what you would need to know to proceed toward a repository design and then

license application.

So, I think our concern is that, one, more could be done to accelerate the site suitability determination and that's why we keep emphasizing the need to get underground. But two, assuming that the site is found to be suitable, to do the long lead time investigations where the systems interactions of transportation and storage become quite critical so that one can then proceed to the next step if the site is found to be suitable.

COMMISSIONER ROGERS: But it sounds to me as if you're saying that the site suitability is reasonably well decoupled from the other two -- the storage and transportation issues.

DOCTOR ALLEN: Well, let me give one example where there is some coupling and an area of my own interest. That's the problem of earthquakes and perhaps faulting through the loading facility. If we had a universal cask where it was not necessary to go into a hot cell and exchange this material at the site itself, this would drastically change the possible affects of surface faulting through the repository or through the loading facility. So, here's a case where at least in terms of surface faulting, which is part of suitability considerations, is closely related to

canister -- the possibility of a universal canister, which is part of the overall systems management concern.

COMMISSIONER ROGERS: Well, I'd like to just -- I have a couple questions on the canister, but following this on the site itself for the moment, do you know of any outstanding issues that could be dealt with by surface-based studies that are still out there now that could be dealt with just with surface-based studies? I know your emphasis has been getting underground.

DOCTOR NORTH: There are clearly very important issues to be dealt with with the surface-based studies and a number of these have been addressed in various documents from NRC and from DOE and from the National Academy review of the Szymanski hypothesis. The question of understanding the steep hydraulic gradient near the site and then the relatively flat gradient in the down gradient direction, we would like to know more about why that is the case to have a better understanding of it and deep drill holes from the surface appears to be a very useful way to pursue that investigation. So, clearly completing that program is a very important thing to do.

Similarly, our next meeting will be on the issue of climate change and infiltration. There again, the surface drilling program, in this case the shallower holes, is really quite critical for understanding the behavior of infiltration given the incident precipitation. The gaseous pathway certainly is another one where the surface-based investigations will be extremely critical. As our Chairman Cantlon mentioned, we are interested in learning more about Nevada's concern with regard to the underground exploration potentially compromising the investigations of the gaseous pathway.

COMMISSIONER ROGERS: With respect to the universal cask concept, do you have any feeling about how fundamental the adoption of such a system would -- how fundamental an effect it would have on the design of the repository? And the thermal loading potential, for instance, would it change that in some way?

DOCTOR NORTH: Yes.

COMMISSIONER ROGERS: I would imagine it would.

DOCTOR NORTH: For example, one might go to a much larger, more robust container which perhaps would be in the form of an inner container that is loaded at the repository and used for storage

transport and then final disposal. But in transportation it has one over pack, in disposal it has another over pack that would provide, for example, the radiation shielding. It might be placed on rail transport within the repository rather than emplacement in a bore hole. In this way, there could be some flexibility with regard to the thermal loading issue. If you find you need to reduce the thermal loading, this means you can move the device perhaps remotely on the rails. It's not in a hole in the rock.

COMMISSIONER ROGERS: Yes.

DOCTOR NORTH: Furthermore, with horizontal emplacement in the drift of this kind, perhaps on rails, this means during the period of retrievability, before the repository is sealed, you can air cool it. So, unless you want to do it for experimental purposes, you're not putting the heat into the rock, you're taking it out through the air flow.

So, there are many implications for repository design and many issues of flexibility.

DOCTOR ALLEN: And also increasing concern about the nature of the Ghost Dance fault and how it might do in the repository level. If we could use a

large canister emplaced in the drifts, you have much more opportunity to do free bore, the kinds of things that might possibly sustain or at least mitigate the effects of any kind of fault displacement of depth, as compared to putting it in a bore hole only a centimeter or so of air gap.

DOCTOR CANTLON: Also, if you go to the larger canister design and you're not going to emplace it vertically down a bore hole, the head room that you need in the drifts is smaller and so the cost of building a repository could be reduced as well as the cost of filling it back in afterward.

So, a number of issues that feed back between that, and it is in our view the lack of this system's look at the interplay of these parts rigorously justifying the choices that are made at these steps is the weakness of the program.

CHAIRMAN SELIN: Commissioner Curtiss?

Commissioner Remick?

COMMISSIONER REMICK: When you continuously stress early determination of site suitability, I assume you're talking about site suitability or unsuitability.

DOCTOR CANTLON: Absolutely. Oh, amen.

COMMISSIONER REMICK: I took that as a

given.

On your hypothesis that perhaps one should consider higher thermal loadings and so forth, keep above boiling, I thought that back some time ago that there was some tests done to determine that under certain conditions, and those were, if I recall, elevated temperatures and geologic pressures, that if you were using I think it was borosilicate glass, that you'd get extensive fracturing, therefore increasing the surface area. And therefore if you had a failure of the canister, a greater chance of leaching.

Have those thoughts gone into this or are you saying these are the type of things that should be considered?

DOCTOR ALLEN: That's one of the very reasons for long-term thermal testing, is to get at this problem of possible fracturing, of mineralogic change. So, yes, that's the very reason for doing these kinds of long-term -- and the necessity for doing these long-term tests.

DOCTOR CANTLON: And building on that, we mentioned the testing of the canisters in situ at elevated temperatures and so on to look at their susceptibility to corrosion. The same thing needs to be done with the glass, the borate glass and of the

defense waste. You need to study the behavior of those things at these elevated temperatures as well.

COMMISSIONER REMICK: One other area. I'm not sure if I agree with what you said, but I have a feeling that maybe it's just a difference in use of terminology. You were talking about that we do not permit the best available technology and I wonder if that -- I think of that as best available technology. I wonder if you aren't talking about if we don't use better approaches where you can balance one thing from another. As we have it now, we have basically a series of requirements and insisting that you meet those.

One of the problems I've always had with the words "best available technology" and my interpretation of it, you can require that you use a technology that is excessive for the need. In other words, it's more costly perhaps and you go beyond what is really needed from a standpoint of safety. I don't think that's what you're talking about. Nor do we, in meeting any one of these --

DOCTOR CANTLON: No.

COMMISSIONER REMICK: -- in the waste form or engineered barriers or geology, are we preventing the use of any particular technology, but maybe we're

not -- the overall systems approach we're not using.

DOCTOR CANTLON: Yes. We mean it in the earlier, not the later sense.

COMMISSIONER REMICK: Okay. All right.

DOCTOR NORTH: I think you should recognize that our responsibility is to the DOE program and therefore we deal with a lot of perceptions of NRC regulations from DOE.

COMMISSIONER REMICK: Yes.

DOCTOR NORTH: Now, as the Board began its operation in 1989, we found that there was the perception that the NRC regulation prohibited taking credit for a canister that would last more than 1,000 years. Now, we raised that question and it was subsequently clarified that that wasn't what you intended, but that was what DOE told us they thought you intended.

COMMISSIONER REMICK: That came up, not that particular one, with the ACNW a week or so ago and I pointed out to them that this bit of us not allowing to take credit in one area or another was something that DOE itself proposed and the NRC accepted.

DOCTOR NORTH: Our point is, these dialogues on where flexibility might be important and

trade-offs should be considered may be much more effective if they happen earlier than if they happen in a license application process where changing the regulations might be regarded as caving in in order to go forward with a repository which doesn't meet some of the criteria that was established in advance.

CHAIRMAN SELIN: Commissioner de Planque?

COMMISSIONER de PLANQUE: Yes, just a couple of questions.

Based on your observations in other countries, you've mentioned a few aspects of their programs that you think the U.S. should consider like their approach to scheduling or less prescriptive regulations. Are there any other aspects of the programs that you've looked at that you think the U.S. should be considering?

DOCTOR CANTLON: Well, I think because in most of the countries that we have visited the utility industry remains responsible and liable for the fuel, we think we're almost at the other extreme in which the government essentially exempts the utility and all the private sector from any future involvement and we think there may be some reason for getting somewhat more interplay, getting the utilities back into the dialogue and looking at the extreme heterogeneity of

the U.S. utility world as opposed to much greater homogeneity in most of the foreign utility world. So we think, as we listen to their representatives, they clearly are getting more and more nervous as 1998 gets closer and closer and so we really do believe that we could learn something from our foreign colleagues in this regard.

COMMISSIONER de PLANQUE: Okay.

Would you care to comment on how you view the role of reprocessing in the spent fuel management programs of other countries?

CHAIRMAN SELIN: The answer is, probably, no, he doesn't want to --

COMMISSIONER de PLANQUE: I don't think he wants to, but I thought I'd try.

CHAIRMAN SELIN: But he's going to do it anyway.

DOCTOR CANTLON: Yes. I think the short answer is the Board has not discussed it. As a matter of fact, in one of our earliest meetings we talked about the fact that we were by our mission constrained with what the U.S. policy was.

DOCTOR ALLEN: It's not on our mandate.

DOCTOR CANTLON: It's not on our mandate.

DOCTOR NORTH: On the other hand, I think

there is a relationship with the retrievability issue as we've presented it to you.

COMMISSIONER de PLANQUE: Yes, right.

DOCTOR CANTLON: Absolutely. And looking out long-range, if new energy technologies and greater efficiencies in U.S. energy consumption are not forthcoming at a rate that we need for economic growth and if we are really to give developing countries access to fossil fuel supplies at something approaching economically acceptable levels, then the advanced technical countries are going to have to look at all of the exotic energy systems. And the only one that's on the shelf ready to be picked off is nuclear.

COMMISSIONER de PLANQUE: Do you have any indications that there would be a possibility of declaring spent fuel mixed waste? And if so, what does that do to the whole program?

DOCTOR CANTLON: We've been through the WIPP exercise and we know the chaos that that created.

Well, that clearly gives us a regulatory challenge that would require legislative addressing and I guess the only thing that could be said usefully from my level of understanding of the issues is that when the Congress believes that it has an important national problem that it's created by its laws, they

have had the good judgement to change the laws.

COMMISSIONER de PLANQUE: Okay. Thank you. I've found this very useful and informative.

CHAIRMAN SELIN: Commissioner Rogers has another question.

COMMISSIONER ROGERS: Yes, I just had one question. This question of doing the heated rock experiments is an interesting one, the length of time that it would take to do this. I think you were saying you thought it might take a decade. Are there any natural scale lengths that one would bring in here to say what's the minimum physical size of an experiment that would be conducted?

DOCTOR ALLEN: Any natural --

COMMISSIONER ROGERS: Scale lengths. I mean, either from a geologic point of view or --

DOCTOR CANTLON: Natural analogue sort of things?

COMMISSIONER ROGERS: Well, I don't know about natural analogues, but some of the phenomena that you're looking for and looking at may have some kind of a natural yard stick over which --

DOCTOR CANTLON: You'd need a full container, in other words?

COMMISSIONER ROGERS: Well, yes. I mean,

you know, less than ten feet doesn't make any sense at all or something like this, some scale by which one might estimate how large an experiment would have to be conducted.

DOCTOR ALLEN: I think it would be very difficult to scale these up or down for the same reasons. The temperature you can't drive up twice as high and do it in half the time. Many of these effects are nonlinear and we don't really understand those very well, so I think in order to get public and scientific acceptance we're going to have to do these things essentially at full scale, the tests.

DOCTOR CANTLON: Some of the European experiments that are in place with heaters are a reasonable approximation to the kinds of waste containers that they're talking about, somewhat scaled down.

DOCTOR NORTH: But you may not have to do an experiment that is essentially repository scale, maybe one or several containers and the rock in the vicinity of those containers which might perhaps be on the order --

COMMISSIONER ROGERS: That's what I'm talking about.

DOCTOR NORTH: -- of tens of meters, as

opposed to --

COMMISSIONER ROGERS: Not talking about a table top.

DOCTOR NORTH: No. We're not talking about kilometers, but, on the other hand, you do need to be able to look at the accumulation -- in other words, what happens when you put many of these modules together -- but that is perhaps something that can more reliably be done with computer programs. You need the basic data on what happens on a scale of meters to tens of meters and at this point we really do not have that.

CHAIRMAN SELIN: Commissioner Remick?

COMMISSIONER REMICK: Yes. Without indicating my personal preferences, I want to go back to your question of retrievability. If you really have concerns about being able to monitor the possibility of air cooling, the possibility of retrieving and so forth, doesn't an above ground facility make all those much easier than a deep geologic repository, if those are concerns?

DOCTOR CANTLON: The real question is, are you willing to live with the greater risk that clearly an above-ground repository presents? It's very difficult to hide a drill rig and drill rig activity

or the other kind of penetration that would take place getting into a repository. The recent event at the Three Mile Island reactor sort of gives one the impression that it's relatively easy to run a vehicle through a gate. The event in New York City --

COMMISSIONER REMICK: So you place the risk of sabotage above the other risks that you were referring to and retrievability and --

DOCTOR CANTLON: Well, I don't know whether -- I'm not a risk person.

DOCTOR NORTH: As the risk person present, let me see if I can give you a very simple characterization. We have not done an analysis of potential for terrorism and sabotage. I've given you my understanding of the vulnerability of dry cask storage as it's been described to me.

If you put the waste underground in what I will call an underground monitored retrievable storage facility which when closed could become a permanent geologic repository, that is clearly a great deal more expensive than something one could do on the surface.

Now, some people I know in the decision analysis, risk analysis community have recently done a study looking at strategic options for nuclear waste

and they find with an economic analysis that interim storage on the surface and waiting until 2100 is a much cheaper alternative. I'm not sure I should be surprised by that conclusion. The policy issue, I think, is the one that Congress has dealt with in the '82 and the '87 Acts, do we have a national commitment to put the waste underground in permanent geologic storage? It seems to me that's really not a question that our Board has been asked to address. We've rather been asked to address the technical program to implement that objective.

COMMISSIONER REMICK: That was my intent because you talked about monitoring, retrievability, the possibility of air cooling. Now you're saying, "Isn't it true that from technically that would be easier if it was above ground than below ground?"

DOCTOR NORTH: But what you get with a system where you could air cool and have the flexibility to move the waste easily underground is you get more flexibility than going ahead with a program that is centered on meeting the Nuclear Waste Policy Act goal of an underground repository, but does not provide for the flexibility that perhaps in the next several generations people might change their mind and decide either we want to do the technology

differently or spent nuclear fuel is a valuable material and we might want to retrieve it.

So, as one who has been trained in risk and decision making under uncertainty, I feel this uncertainty about the future uses of the spent nuclear fuel and the future technological alternatives would suggest that we might want more flexibility in the design of the repository.

CHAIRMAN SELIN: Well, I'd like to thank you very much, but I do have one question for you, which is a trick question. I'm impressed by just how sensible your advice is and in some places how far it is from what we see in the program and would like to ask you why hasn't more of your advice been followed? I don't mean that as a joke, but it's sort of obvious -- well, it's wonderful, sophisticated, high technical advice, but the results are so obvious in a number of places. What are we missing? Why aren't more of them being carried out?

DOCTOR NORTH: I'll take that one, at least to start off and then my colleagues can add.

We have emphasized in this presentation to you areas where we believe that the DOE should be changing course. We are giving advice in areas where it hasn't yet been accepted. In many other areas, in

particular the design of the underground exploratory study facilities, we have given an advice that has been to a very large extent accepted by the Department of Energy.

DOCTOR CANTLON: Yes. The overwhelming number of recommendations that we've made have been accepted by the DOE. What we're reporting in a sense is a residue. Not surprisingly, they're the more difficult ones to cope with.

CHAIRMAN SELIN: Well, I mean that sounds fine, but this discussion about doing a plan and how to do a plan doesn't sound all that complicated.

DOCTOR CANTLON: That's the one disappointment, I think, that the Board feels that getting a really solid approach to a systems view of the total system, why has it taken this long --

DOCTOR ALLEN: We have emphasized that from the time of our very first report.

DOCTOR CANTLON: The first report identified it. And we were very pleased when the M&O was brought on. That is an organization that has a track record in that field. I guess we're even more disappointed now that having a competent M&O on, it hasn't really resulted in the kind of thing that we expected and maybe we'll see it. We're hopeful.

DOCTOR NORTH: Well, we should, perhaps, add we haven't seen it yet. We understand they're working on it and they may be quite upset by our disappointment and impatience that the product, the planning has not yet emerged into public view. We would encourage them to proceed with all deliberate speed and we hope that some of our concerns about the deficiencies can be rapidly and effectively remedied.

CHAIRMAN SELIN: Fine. You're a public board? All your meetings are open?

DOCTOR CANTLON: All of our meetings are open and all of our panel meetings are open.

CHAIRMAN SELIN: Fine. Thank you on behalf of my colleagues. It was very nice of you to come up.

DOCTOR CANTLON: Thank you for inviting us.

CHAIRMAN SELIN: It's an illuminating and actually a diverting afternoon. Thank you very much. I hope we'll continue to have the opportunity to hear from you on a periodic basis.

DOCTOR CANTLON: Thank you very much.

(Whereupon, at 4:13 p.m., the above-entitled matter was concluded.)

## CERTIFICATE OF TRANSCRIBER

This is to certify that the attached events of a meeting of the United States Nuclear Regulatory Commission entitled:

TITLE OF MEETING: BRIEFING ON ACTIVITIES OF NUCLEAR WASTE TECHNICAL REVIEW BOARD

PLACE OF MEETING: ROCKVILLE, MARYLAND

DATE OF MEETING: MARCH 3, 1993

were transcribed by me. I further certify that said transcription is accurate and complete, to the best of my ability, and that the transcript is a true and accurate record of the foregoing events.

Carol Lynch

Reporter's name: PETER LYNCH

# The Department of Energy's Program to Manage

# Spent Fuel and High-Level Radioactive Waste

# and

# The Role of the Nuclear Waste Technical Review Board

**Dr. John E. Cantlon**
**Chairman, Nuclear Waste Technical Review Board**

**U. S Nuclear Regulatory Commission**

*March 3, 1993*
*Rockville, Maryland*

LXR229V6

[VIEWGRAPH 1]

Good morning, ladies and gentlemen.

It is a pleasure to be here this afternoon. My name is John Cantlon, and I am Chairman of the U. S. Nuclear Waste Technical Review Board. Accompanying me are Board members Clarence Allen and Warner North. I will be talking about the Board and its perspectives on the Department of Energy's program to manage spent fuel and high-level defense waste. I thought you may also be interested in some Board's thoughts about the NRC's role in this effort, so I will close my remarks on that topic.

[VIEWGRAPH 2]

As you know, the Nuclear Waste Technical Review Board was created by Congress in the 1987, Nuclear Waste Policy Amendments Act and is charged with evaluating the technical and scientific aspects of the DOE's waste management program, including site-characterization activities and activities relating to the packaging and transport of high-level radioactive waste and spent nuclear fuel. As you are also aware, the Board, is *not* part of the Department of Energy.

[VIEWGRAPH 3]

Members of our Board are nominated by the National Academy of Sciences and are appointed by the President. I have served from its start and became its second chairman last year. We currently have ten of a possible total of eleven members. I have listed them for you on the viewgraph. We all serve part-time.

The Board is organized into seven panels. They are shown on the next viewgraph.

[VIEWGRAPH 4]

To provide you with some background on the Board, I would like to outline briefly how the Board operates and then summarize some major recommendations we have made to the Congress and the Secretary of Energy in our recent reports.

Our primary mode of operation has been to hold meetings of the full Board or of smaller Board panels. These meetings are open to the public. Participants include the DOE, its contractors, electric utilities, regulatory bodies, the state of Nevada and affected counties, and others who are involved in, or concerned about, the evolution of the U.S. radioactive waste management program.

We have also made a concerted effort to increase the Board members' knowledge of different approaches to the management of radioactive waste. To date, the Board as a whole has visited and met with experts in spent-fuel and high-level waste management programs in Canada, Finland, Germany, Sweden, and Switzerland. The Board's Panel on

the Engineered Barrier System visited Japan last year, and this year we plan to examine the programs in Belgium, France, and the United Kingdom. We have learned a great deal from these interactions.

The Board is required to report to Congress and the Secretary of Energy at least twice each year. So far, the Board has published seven reports summarizing our activities and stating our conclusions and recommendations. The DOE has made a good faith effort to respond to much of our advice. The most recent of these reports, a special report to the new Congress and the new Secretary of Energy, was issued yesterday. It outlines several of the Board's major concerns.

The Board Chairman and staff also have participated a number of times in congressional committee hearings and have received and responded to written questions from those committees. We have also met with representatives of the Office of Management and Budget.

[VIEWGRAPH 5]

During its four year review of the program, the Board has witnessed considerable progress, especially in site characterization and data-collection at Yucca Mountain - *and, based on existing data, no scientific or technical basis has been established for rejecting the site.* The Board believes that individuals working on the program - mostly scientists and engineers - are generally enthusiastic and very competent in their fields.

Following are some of the more important recommendations we have made that we believe can make their efforts more effective.

[VIEWGRAPH 6]

First, the Board has been consistently concerned about determining the suitability of the Yucca Mountain site as soon as possible. If there are features at the site that could render it unsuitable, we need to find that out now — this will minimize unnecessary expenditure of funds on further characterization of that site.

[VIEWGRAPH 7]

Our Board is convinced that underground exploration and the associated experiments at the repository level are crucial to the thorough evaluation of the suitability of Yucca Mountain for repository development[1]. The DOE needs to excavate the underground ESF, or exploratory studies facility; look at the faults at the level of the proposed repository; look at the hydrogeology of the volcanic tuff host rock; and initiate the diverse testing essential to understanding radionuclide retention capabilities of the

[1] *We have, not as a Board, examined Nevada's recent claim that underground exploration may preclude adequate characterization of gaseous pathways in Yucca Mountain.*

rock under projected repository thermal conditions. We need to see what's down there and to evaluate how it will behave if a repository were sited there.

The Board has recommended that the most effective and efficient way of conducting this underground exploration is through the use of tunnels excavated by means of mechanical tunnel boring machines. Present plans call for portal construction to take place this year; start-up of the tunnel boring machines by March 1994, and completion of the ESF by 1998.

We also have recommended that the DOE use more cost-effective small diameter tunnels which are all that's necessary to evaluate site suitability and to conduct site characterization. Then if the site proves suitable and if larger diameters prove necessary to accommodate the requirements of a permanent repository, the tunnels can then be scaled up. Some critics have noted that building the larger diameter tunnels now, as presently being planned, creates the perception that the DOE is building the repository at the same time it is testing for site suitability. We believe an intermediate size tunnel diameter is emerging and getting underground quickly and conducting the necessary tests is of greatest importance.

[VIEWGRAPH 8]

A second issue that concerns the Board is the low priority the DOE has placed on studies of different types of engineered barriers. The DOE's 1988 base plan relies on the engineered barrier system for radionuclide retention for only the first 300 to 1,000 years and proposes borehole emplacement using thin-walled, non self-shielding containers.

[VIEWGRAPH 9]

The Board believes, and has recommended, that the DOE place greater reliance on the engineered barrier system as a way to build redundant radionuclide containment into the repository design. This redundancy, in our view, should help reduce concern about repository safety, especially in the face of the inevitable uncertainties associated with predicting natural geologic, hydrologic, and climatological processes far into the future.

The Board has tried to highlight the importance of engineered barriers — including use of a robust long-lived waste package — to the entire waste management system. Considering different engineered barrier design concepts, for example, means considering different repository designs, different options for waste emplacement and repository closure, and different containers, as well as alternatives in the packaging, storage, and transportation components of the waste management system.

[VIEWGRAPH 10]

With respect to designing the waste package itself, the Board believes that extensive materials testing is required. Of greatest importance is determining how

various materials will hold up over long periods of time under possible underground conditions. Despite this strong Board position, the DOE has chosen to accommodate its budget constraints by reducing funds going to the waste package development program. We believe it unwise to defer studies in this area.

The third issue is repository thermal-loading. The choice of repository thermal loading has wide-ranging implications for the geology of the site, for the engineered barrier system, and for the entire radioactive waste management system. We found this issue so important, that we held a three-day conference on thermal loading in October 1991.

[VIEWGRAPH 11]

As we see it, there are two basic approaches to thermal loading: the temperatures in the repository can be kept either (1) below or (2) above the boiling point of water. Most countries are evaluating the potential of locating a repository at levels located below the water table. They assume that repository temperatures will be kept below boiling for the lifetime of the repository.

[VIEWGRAPH 12]

The DOE's 1988 base-line strategy at Yucca Mountain calls for high initial temperatures above the boiling point of water for the first 300 to 1,000 years, with temperatures then falling below boiling.

The theory behind the DOE's base-line strategy is that above-boiling temperatures would drive away any liquid moisture that might otherwise make contact with the waste containers. This should prevent, or at least greatly retard, corrosion of the waste containers and the transport of radionuclides for at least 300 years. How the long term hydrogeology and radionuclide retention capabilities of the rock will actually perform under high temperatures and the eventual temperature decrease has yet to be tested and validated.

An alternative long-term above-boiling strategy was outlined briefly at the Board's October 1991 meeting. The theory behind the long-term above-boiling strategy is that, if it is good for waste isolation to keep temperatures above the boiling point of water for 300 to 1,000 years, as in the base plan, keeping temperatures above boiling for thousands of years may prove even better for the long-term engineered barrier containment of the radionuclides. This would allow for considerable radioactive decay before liquid comes into contact with the waste containers. The long-term heating impact on radionuclide retention — especially if future regulations extend beyond 10,000 years — clearly needs to be estimated.

[VIEWGRAPH 13]

It is important to remember that the thermal strategy chosen will affect the entire waste management system. It will affect how much waste can be put in one repository; how the waste will be loaded in containers; how long waste must be aged prior to disposal; how the waste is packaged, handled, transported, and emplaced in the repository; and how and when the drifts are back-filled. Finally, it will affect how much the overall waste management program will cost.

[VIEWGRAPH 14]

We believe there are many uncertainties involved with each thermal-loading strategy and these uncertainties and the hypotheses associated with them must be evaluated more thoroughly. Early initiation of long-term tests in heated rock at the repository level is critical.

[VIEWGRAPH 15]

Once the DOE has evaluated several strategies, and their potential effects on the waste management system, a thermal-loading strategy that best assures safe, long-term waste isolation can be chosen. Much work still needs to be done.

[VIEWGRAPH 16]

The fourth issue, relates to the fact that waste management, that is, the transport, storage, and disposal of spent fuel and high-level waste, should be viewed as an overall system whose separate elements and sub-elements can be highly interdependent. At best, the failure to adequately account for these interdependencies can lead to less than optimum configurations. At worst, it can lead to errors that require costly and time-consuming remediation. I previously mentioned the importance of choosing a thermal—loading strategy for the repository and indicated its implications for all waste management system components. I would like to provide four additional illustrations of important system considerations.

[VIEWGRAPH 17]

(1) The DOE's baseline plan for the interim storage of radioactive spent fuel requires constructing a centralized interim storage facility in time to begin accepting spent fuel from the utilities by January 31, 1998.

However, on December 17, 1992, in a letter to Senator Bennett Johnston, Chairman of the Senate Committee on Energy and Natural Resources, then-Secretary of Energy Watkins acknowledged that no voluntary site for the central interim storage facility had been identified that would allow the DOE to meet the 1998 deadline. He asked Congress to authorize and direct the DOE to select alternative candidate sites for interim storage of spent fuel at federal government sites. Considering initial reactions

from potential host states, this option also may prove difficult to implement. It therefore appears unlikely that any centralized interim storage facility will be available to begin accepting spent fuel from the utilities by 1998.

Currently, there are approximately 25,000 metric tons of spent fuel stored at reactor sites around the country, and this amount is being added to at the rate of about 2,000 metric tons per year. Under existing law, the capacity of a centralized facility is limited to only 10,000 metric tons before repository operations begin. Even if a centralized storage facility with the current limit on capacity were constructed and a repository at Yucca Mountain were developed according to the DOE's schedule, substantial amounts of spent fuel will probably remain in storage at reactor sites for decades. Yet, the implications of extended interim spent fuel storage, at whatever site, have not been adequately addressed in the DOE's waste management total system planning.

The safety of interim storage does not appear to be a serious technical problem. Your Commission, in the Waste Confidence Proceedings, has determined that spent fuel may be safely stored — wet or dry — for at least 100 years. However, some utilities have met with resistance when requesting permits from state and local authorities to use dry cask storage, due in large part to lack of strong evidence that a repository will be available in the foreseeable future.

As discussed in the Board's *Sixth Report*, in other countries visited by the Board the need for extended interim storage for all of the spent fuel is anticipated and integrated into their waste management plans.

[VIEWGRAPH 18]

(2) A second example that illustrates these strong system interdependencies is the waste container. In the past the DOE has considered separate containers for storage, transportation, and disposal. This approach calls for reconfiguring the waste container as the function changes. Opportunities for human error, equipment failure, and radiation exposure increase as the frequency of human handling increases.

Some nuclear utilities, faced with the prospect of long-term on-site storage, have investigated multipurpose container concepts that could be used to store, transport, and, perhaps, to dispose of the spent fuel. The DOE also is increasing its efforts to develop a multipurpose container. Such a container could greatly reduce the risk of radiation exposure and obviate the need for routine hot cell transfer beyond the utility sites. Its consideration, however, requires a careful evaluation with respect to all the separate elements of the overall waste management system.

[VIEWGRAPH 19]

(3) One topic that we believe has not received sufficient attention is the fact that the repository will contain other waste forms aside from spent fuel. For example, the

special problems posed by the disposal of *high-level defense wastes* should be evaluated and integrated into DOE's plan to manage *all* high-level radioactive waste. Current estimates of the number of canisters that could come from defense facilities range from 15,000 to more than 200,000. This could result in a more complicated and difficult design process for the disposal system. Other high-level radioactive wastes, such as the Three Mile Island-2 core, spent naval reactor fuel, and other defense reactor spent fuel also will probably require disposal in a repository.

[VIEWGRAPH 20]

(4) Finally, we have to examine how long the spent fuel should remain *retrievable* after it has been emplaced in the repository. The 1988 base plan design calls for the Yucca Mountain repository to meet the 50-year NRC retrieval requirement. However, there may be advantages to a longer retrieval period, such as being able to monitor waste package performance or recover spent fuel for economic or other reasons. There also are disadvantages such as the costs associated with monitoring and maintaining the repository after it has reached capacity. The pros and cons associated with various retrievability options should be analyzed thoroughly now — before decisions are made that could limit the system's retrievability options.

[VIEWGRAPH 21]

The Board believes that the DOE should place very high priority on developing a comprehensive, well-integrated systems-oriented plan for the overall management of all the spent fuel and high-level waste from generation to disposal. This plan, developed iteratively, should be based on a systematic assessment of options related to the storage, transport, and disposal of spent fuel and high-level waste.

[VIEWGRAPH 22]

A fifth issue has to do with the management of the radioactive waste program. The civilian radioactive waste program encompasses work undertaken by the DOE, its dozen or so private contractors, a number of national laboratories, and the U.S. Geological Survey, as well as many others. The number of people working on the program now totals almost 2,000 (roughly 200 DOE employees and 1,750 contractor employees). The program's organizational structure is multilayered and the entities are geographically dispersed. Responsibility is shared among these entities and seems to be diffuse.

[VIEWGRAPH 23]

This large and unwieldy organizational structure also creates substantial integration problems. Although a management and operations contractor was hired in

1990 to consolidate and integrate program activities, the DOE doesn't seem to be using the management and operations contractor effectively. Integration remains a major problem that contributes to inefficiencies in the program especially in the development of a well-integrated waste management plan. The lack of such a plan affects all aspects of the technical and scientific program.

Another Board concern in the area of management is funding allocation decisions. For example, in fiscal year 1993, funding for overhead and infrastructure — according to the DOE, the basic costs necessary to keep the program operating — will account for approximately 56 percent of total funds for site characterization. Allocating such a high proportion of funds to overhead and infrastructure leaves limited funding for important testing and research and may have already contributed to delays in the initiation of underground excavation and in the development of a long-lived waste package.

[VIEWGRAPH 24]

Other countries visited by the Board provide interesting alternatives to the U.S. program's organizational approach. For example, in some countries, a government-sponsored corporation or organization has been created to implement radioactive waste management programs. In addition, in most of the countries the Board has visited, nuclear waste producers are responsible for safely managing nuclear waste — including in most cases planning, financing, and executing all research, interim storage, transportation, and disposal activities. There seems to be more financial and managerial accountability in these countries, and their programs appear to be more effectively managed than in the United States.

Alternatives to the current U.S. organizational and management approach were evaluated in two congressionally mandated studies in the mid-1980s. Since then, no detailed comparison of the U.S approach with alternative approaches has been undertaken. However, Secretary O'Leary at her confirmation hearing in January indicated that she may undertake a review of the civilian radioactive waste management program.

[VIEWGRAPH 25]

The Board believes that the effectiveness of program management and integration needs to be improved and that the program would benefit from a thorough independent review of its organizational structure. Taking a look at the approaches being used in other countries could be useful in such a review.

[VIEWGRAPH 26]

The final Board recommendation I would like to discuss today is what we believe to be the negative effect of unrealistic deadlines. The 1982 Nuclear Waste Policy Act authorized the DOE to enter into contracts with the utilities for the acceptance, transport, and disposal of their spent fuel. According to the Act, federal acceptance of

spent fuel for disposal in a repository was to begin by January 31, 1998. I might add that the U.S. program is the only program the Board is aware of that has been given a legislatively mandated date to begin disposal of spent nuclear fuel.

In January 1987, realizing that this deadline could not be met, the DOE changed the planned start-up date for repository operations to 2003, only to change it again two years later to 2010.

The original 1998 date for repository operations slipped because it was not based on a realistic assessment of the technical requirements of the program. According to the DOE, to meet the 2010 goal it will be necessary to submit an application to the Nuclear Regulatory Commission by 2001 for authorization to construct the repository. Before filing an application for construction authorization, DOE must first make a determination of whether or not the site at Yucca Mountain is suitable for repository development. However, the Board is concerned that there may not be enough time to complete the critical technical activities necessary to make the decisions to meet by these dates.

[VIEWGRAPH 27]

For example, the planned long-term heater tests, vital to determining the validity of assumptions underlying the choice of a thermal loading strategy are not scheduled to begin until 1996 and may require a decade or more to complete. There also may not be enough time, at present funding levels, to adequately evaluate the long-term behavior of materials, under repository conditions, information needed for waste package design.

A number of other factors beyond the DOE's control could contribute significantly to further delays in program progress and affect the current schedule. For example, to meet its 2001 deadline, the DOE has said that it will need an average of approximately $600 million per year for the next seven years just *for site-characterization* activities. The DOE has never submitted a request to Congress for funding at anything approaching this level. Current funding for the entire Office of Civilian Radioactive Waste Management program is approximately half this amount.

Another factor is the Energy Policy Act of 1992. Any changes in the current EPA standard or in the NRC's requirements could affect test plans and require changes in the design of the waste package and the repository.

Also in the Board's view, there just isn't any room in the current schedule to accommodate unforeseen technical uncertainties or institutional problems that inevitably arise during unpopular, first-of-a-kind projects.

[VIEWGRAPH 28]

Considering past delays and the potential for future delays, the Board seriously doubts that either the 2001 deadline for construction authorization or the 2010 repository development deadline can be met. The Board's concern rests in the fact that *attempting*

*to meet* current unrealistic deadlines may force the DOE to make decisions about important technical aspects of the program without first performing adequate and appropriate technical and scientific analyses.

[VIEWGRAPH 29]

The Board supports adopting the approaches of other countries it has visited, where accountability efforts are focused on achieving *interim* technical milestones, and where schedules for repository operation are tentatively set based on a realistic assessment of program requirements. Most other countries visited by the Board have set a goal for developing a permanent place to bury their waste by 2020 or later.

There could be many advantages associated with establishing a new, more flexible long-term schedule that incorporates firm target dates for interim goals, such as getting underground, determining site suitability, and completing essential testing. Decisions made under pressure can lead to mistakes and costly remediation or potential licensing problems. Adopting a more realistic schedule may actually speed *real* program progress and improve the system's cost effectiveness over the long run.

I would like to conclude my presentation today with some comments the Board has with respect to the NRC's role in the current process. In addition to personal contacts and to reading the NRC staff positions on technical issues, the Board has heard the NRC's viewpoint at Board meetings, at DOE-NRC technical exchanges, and at the very informative meetings of the Advisory Committee on Nuclear Waste. We are impressed by the quality and openness of these interactions and wish to express the Board's thanks.

[VIEWGRAPH 30]

There are several issues that we would like to suggest you look at.

First is the issue of regulations. We, in our previous reports — as well as the National Academy of Sciences in its 1990 report on "Rethinking High-Level Radioactive Waste Disposal," — have touched upon problems associated with the technical aspects of the standards and regulations be used in determining site suitability and repository construction and licensing. The Board noted from its trips abroad that, in those countries visited, the regulations used with respect to the disposal of spent fuel and high-level waste are less prescriptive than the U. S. regulations. All of these countries currently have a more flexible approach than the United States and this allows considerable flexibility in the application of best available technologies to the waste disposal problem.

As a result of the 1992 Energy Policy Act, the U.S. standards and regulations will be reevaluated.[2] We hope that the Commission will use this opportunity to take an overall look at its regulations with the objectives of clarifying them where necessary and, as it sees fit, incorporating those modifications that allow both more effective protection of public health and safety and a more efficient regulatory framework for constructing and licensing an underground repository.

Second, as stated previously, we believe that the increased emphasis on engineered barriers, including long-lived waste containers, can only enhance scientific and technical confidence in the long-term ability of a repository to contain and isolate harmful radionuclides. However it is not always possible to view engineered and natural barriers as completely independent systems. Indeed trade-offs can be made. A preferred objective would seem to be to design a system of natural *and* engineered barriers that together provide increased and more certain long term protection to the public. A natural hazard that could easily be remedied by good engineering should be viewed in a different light than one that is not as easily remedied.

The ACNW, in its letter of December 1, 1992, raised a similar concern. We support their view that the Commission may wish to examine NRC positions that unnecessarily limit the role that engineered barriers are allowed to play, so as to "ensure that the DOE is not burdened with a requirement that is neither necessary nor feasible to implement and ... contributes little additional assurance of protection of the health and safety of the public."

Third, is the issue of expert judgment. There is little doubt that even the most extensive data-gathering program will not eliminate the need for the use of expert judgment in reaching conclusions on many contentious issues. This has been the experience in the siting and construction of many critical facilities throughout the world. Because of the unique requirement to provide reasonable assurance that the repository will perform adequately for many thousands of years, the use of expert judgment in licensing board hearings may be particularly important.

We have observed that the NRC staff and the DOE do not necessarily agree on how expert judgments should be used. We urge the Commission to initiate a process by which its staff and the DOE can come to some early agreement on the use of expert judgment before licensing hearings begin. The focus of these critical hearings should be the judgments themselves rather than differences over methodology.

Finally, I would like to address the issue of setting priorities. The Board has made a point in its interactions with the DOE of emphasizing the need to set priorities in their investigations — that is, give prime emphasis to those studies that will allow the early determination of site suitability and the resolution of key technical issues. It is our belief

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[2] *Although we have not had a chance to review it, some of us have seen the recent ACNW letter to the Commission on this topic.*

that the more than 100 study plans based on the 1988 site-characterization plan are *not* of equal value with respect to assuring a safe repository.

The Commission may wish to pursue a similar process. It could be useful for the DOE to know your view as to what you believe really counts. This could help the DOE to better focus its energies. We note that the NRC staff has embarked on a program of iterative performance assessment. The staff presented their initial results to the Board, and we believe that such a program can be very useful in assessing priorities.

In summary, I would like to restate several points.

*First:* Based on existing data, no scientific or technical basis has been established for rejecting the Yucca Mountain site as a potential location for a high-level waste repository.

*Second:* Much work is needed to address some of the critical technical and scientific issues. I mentioned the need for early determination of site suitability, the importance of engineered barriers, the critical role played by repository thermal loading, and the need to look at waste management, that is storage, transportation, and disposal as an integrated, interdependent system.

*Third*, nontechnical issues such as organization and schedule can and — we believe — are adversely affecting the program's technical activities. We believe that the DOE needs an independent look at its organizational structure and that realistic schedules that emphasize interim goals need to be established.

However, such reviews of DOE's activities should not impede the accelerating program to examine the repository horizon and initiate long-term experiments in the exploratory studies facility.

*Finally* I touched on the Board's views with respect to the NRC's role and made some suggestions that the Commission may wish to consider. I mentioned the regulations, the need to take another look at the roles of the engineered and natural barriers, the importance of coming to agreement on the employment of expert judgment, and the need for further guidance from the NRC on what it considers to be the more important technical and scientific issues.

I would like to thank you for the opportunity to share with you some of our views. If you have any questions, I or my colleagues will certainly do our best to answer them.

# The DOE Program to Manage Spent Fuel and High-Level Radioactive Waste and The NWTRB's Role

*John E. Cantlon, Chairman, NWTRB*

*March 3, 1993*

# Nuclear Waste Technical Review Board

## Created by Congress in 1987 to:

Evaluate technical and scientific aspects of DOE's civilian spent fuel and high-level waste management program including site characterization, packaging, and transportation.

# Board Members

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# NWTRB Panels

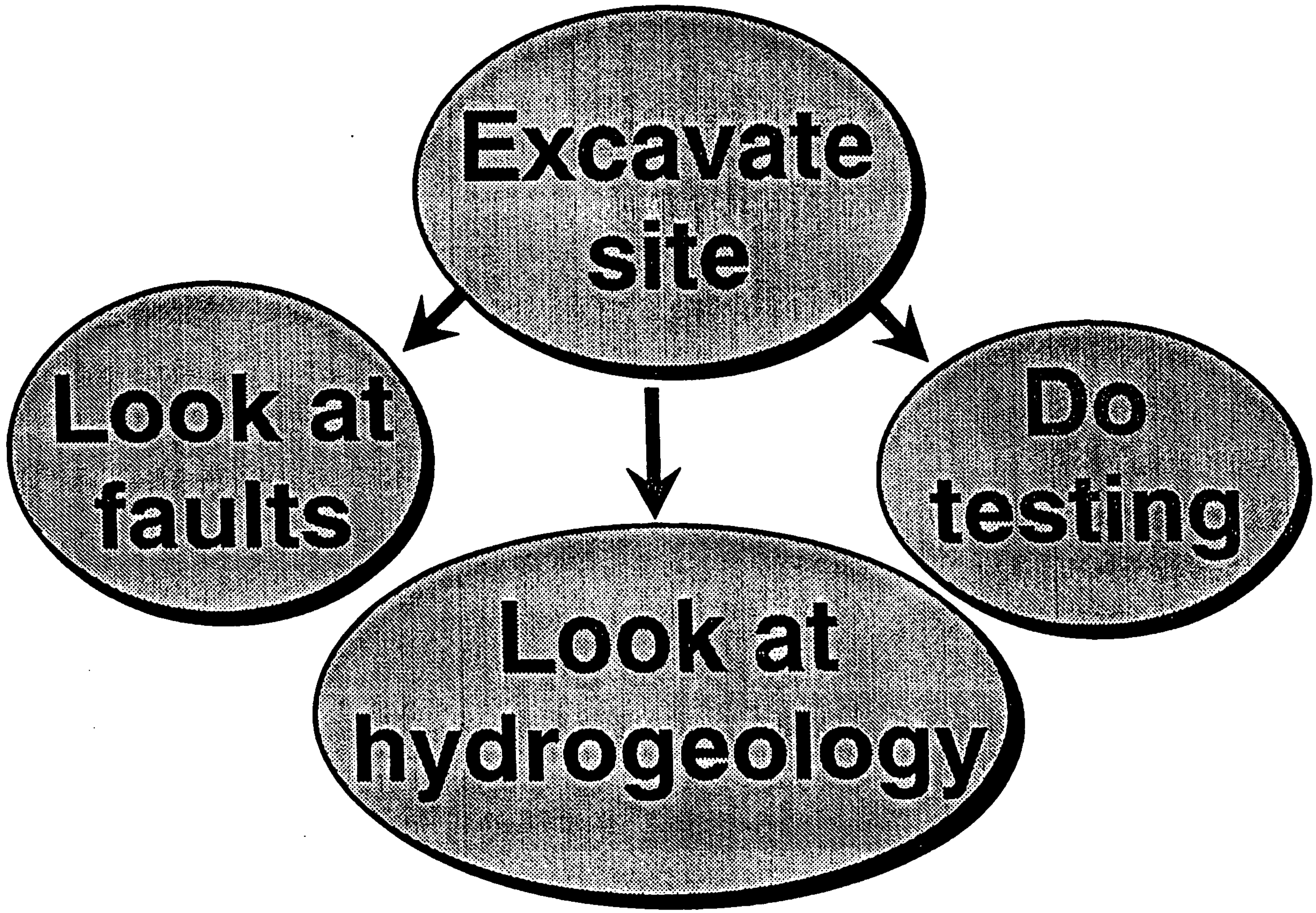
- Structural geology and geoengineering
- Hydrogeology and geochemistry
- Risk and performance analysis
- Transportation and systems
- The engineered barrier system
- The environment and public health
- Quality assurance

**Based on existing data, no scientific or technical basis has been established for rejecting the Yucca Mountain site.**

# Recommendation

**Determine suitability of Yucca Mountain as soon as possible**

# Get Underground



# Engineered Barriers

Department of Energy has placed low priority on studies of engineered barriers

**Engineered Barrier System**

**+**

**Well-Characterized Natural Geologic Barrier**

→ **Increase overall confidence in long-term repository performance**

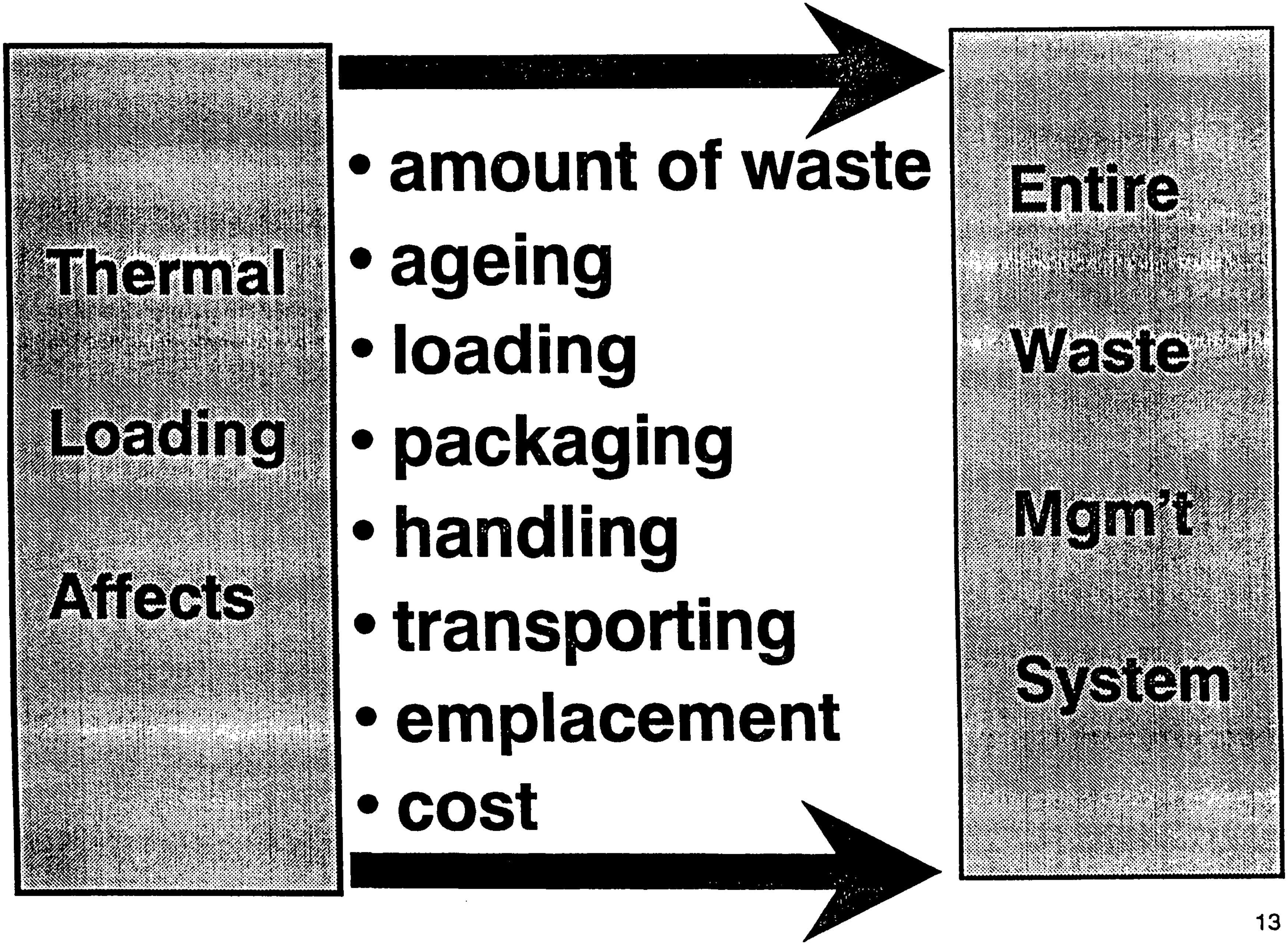
# Recommendation

**Don't defer studies on engineered barriers**

# Basic Thermal-Loading Approaches

- Above boiling in repository
- Below boiling in repository

| DOE Baseline Strategy | Long-Term Above-Boiling Strategy |
| --- | --- |
| • Above boiling: 300 - 1,000 years<br>• Below boiling: After | Maintain above-boiling temperature for thousands of years |


Thermal
Loading
Affects
• amount of waste
• ageing
• loading
• packaging
• handling
• transporting
• emplacement
• cost
Entire
Waste
Mgm't
System

# Issues

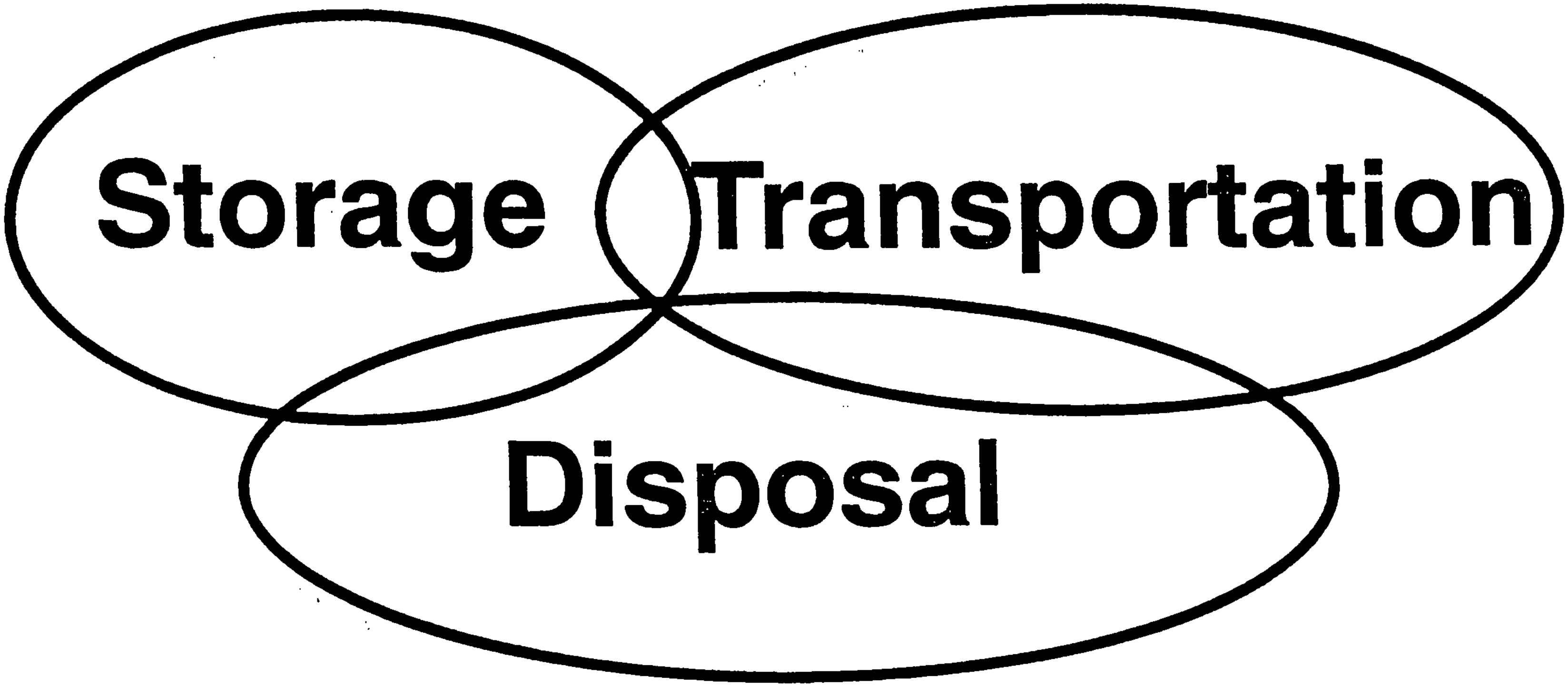
- Many uncertainties with different hypotheses

- Long-term tests in heated rock are critical

# Recommendation

Thorough evaluation of alternative thermal strategies is necessary

# Radioactive Waste Management is a Highly Interdependent System



# Interim Storage

- Long-term storage: a reality
- Not adequately addressed

# Multipurpose Containers

- Could have advantages
- System impacts need to be evaluated

# High-Level Defense Waste

- Insufficient attention
- 15,000-200,000 canisters
- Could affect repository design

# Retrievability

- Presently 50 years
- Longer period may be advantageous
- Options need to be evaluated

# Recommendation

**High priority on well-integrated, overall waste management plan**

# Organization and Management

- Large and unwieldy
- Geographically dispersed
- Diffuse responsibility

# Other Problems

- M&O contractor not being used effectively

- Too much overhead

# Alternatives in Other Countries

- Government-sponsored corporations

- Nuclear waste producers are responsible

# Recommendation

Independent review
of
organizational structure
is needed

# Unrealistic Deadlines

- 2001 - Application to NRC
- 2010 - Repository operation

# Problems

- Critical long-term tests
- Funding
- Energy Policy Act
- Unforeseen uncertainties

Unrealistic deadlines may force important decisions without appropriate analysis.

# Recommendations

- Flexible long-term schedule
- Emphasis on interim goals

# Issues for NRC

- Regulations
- Engineered and natural barriers
- Expert judgment
- Setting priorities

# *NWTRB Special Report*

# *to Congress and the Secretary of Energy*

*Nuclear Waste Technical Review Board*
*March 1993*

# *NWTRB Special Report*

*to Congress and the Secretary of Energy*

*Nuclear Waste Technical Review Board*
*March 1993*

# Nuclear Waste Technical Review Board

# Table of Contents

# Executive Summary

Ten years have passed since the enactment of the Nuclear Waste Policy Act of 1982. During that time, the Department of Energy's (DOE) Office of Civilian Radioactive Waste Management has been developing a system to manage the disposal of spent fuel from the nation's 108 commercial nuclear reactors along with some defense high-level waste. The DOE currently is characterizing a site at Yucca Mountain, Nevada, to determine its suitability for construction of a permanent radioactive waste repository. Surface-based testing at the site is well under way; underground exploration, although delayed for the past three years, is slated to begin in 1994.

Based on its evaluation of the technical aspects of the program, the Nuclear Waste Technical Review Board (the Board) believes that three critical concerns should be addressed to increase the integrity of the scientific and technical program and to improve program effectiveness.

First, the DOE's program is being driven by unrealistic deadlines to begin federal acceptance of spent fuel from utilities in 1998 and to commence repository operations in 2010. The repository development schedule does not reflect a realistic assessment of the technical requirements and nontechnical considerations associated with the development of a geologic repository. The Board is concerned that attempting to meet unrealistic long-term deadlines may force the DOE to make important technical decisions without first performing the appropriate technical and scientific analyses. This could lead to mistakes and costly remediation or potential licensing problems. The Board believes that schedules should be based on realistic target dates for achieving important *interim* goals, such as getting underground, completing critical testing, and determining site suitability.

Second, existing DOE plans for managing spent fuel and high-level waste are not well integrated and contain significant gaps. In developing its plans, the DOE has not considered sufficiently the interdependent nature of storage, transport, and disposal of the waste. Consequently, some important decisions may be made without an adequate technical evaluation of their implications for other components of the waste management system. The Board believes that the DOE should place a high priority on developing a comprehensive, well-integrated plan for the overall management of *all* spent fuel and high-level defense waste from generation to disposal. This plan should be based on a systematic assessment of options related to storage, transport, and disposal.

Third, the large number of organizations involved in the implementation of the U.S. program and the diffuse nature of its organizational structure create substantial challenges for program managers. As a result, management problems seem to be affecting some critical technical aspects of the program adversely. The

Board believes that an independent evaluation of the Office of Civilian Radioactive Waste Management's organization and management should be undertaken. Taking a look at approaches used in other countries could be helpful in such an evaluation.

As the new Secretary of Energy assumes her duties and the 103rd Congress begins its work, the opportunity exists to creatively evaluate the status of this important program. The Board believes that any needed changes to the program can and should be accomplished without slowing the progress of important site-characterization activities at Yucca Mountain.

# Introduction

The Nuclear Waste Technical Review Board (the Board) was created by Congress in 1987 to review the scientific and technical validity of the Department of Energy's (DOE) civilian radioactive waste management program. The goal of the DOE's program is to design and develop a system to manage and safely dispose of the spent nuclear fuel being produced at the nation's 108 commercial nuclear power plants[1] along with some high-level reprocessing wastes from defense-related activities.

During its review of the program, the Board has witnessed considerable progress, especially in site characterization and data collection at Yucca Mountain, and, given existing data, there appear to be no scientific or technical reasons to reject the site at this time. In general, the Board believes that individuals working on the program — mostly scientists and engineers — are enthusiastic and very competent in their fields.

However, designing and implementing a nationwide high-level radioactive waste management system is a uniquely challenging undertaking. For example, a disposal system for spent fuel has never been developed before, and the regulations require that after disposal the waste will not pose a threat to human health and the environment for the next 10,000 years. As a result, there are many different, sometimes conflicting, views about the scientific, organizational, and public policy issues facing the civilian radioactive waste management program. Furthermore, questions persist among the public about all things nuclear and about the DOE's ability to manage radioactive waste.

This *NWTRB Special Report to Congress and the Secretary of Energy* briefly outlines three of the Board's major concerns: (1) the program's unrealistic deadlines, (2) the need for an integrated overall waste management plan, and (3) the effectiveness of program management. The Board believes that these concerns should be addressed immediately, concurrent with ongoing site-characterization work, to ensure that the program has a strong technical and scientific base and to facilitate program progress.

1 108 units with operating licenses; 8 additional units have been granted construction permits (USCEA 1993).

# Spent Fuel and Defense High-Level Waste Management — Evolution of the Current Program

The safe disposal of the country's spent fuel and high-level defense wastes is an issue of long-standing importance. In 1957, the National Academy of Sciences first examined nuclear waste disposal and recommended permanent burial of the waste in underground repositories (NAS 1957). The Board concurs with current worldwide scientific consensus that no technical or scientific factors appear to exist that would prevent the development of a safe underground repository for high-level waste *at a suitable site.*

*... no technical or scientific factors appear to exist that would prevent the development of a safe underground repository for high-level waste at a suitable site.*

Before a judgment can be made about a given site's suitability or final decisions made about components of a radioactive waste management system, extensive surface-based testing and underground excavation and testing must be undertaken and the resulting data carefully analyzed. Presently, the DOE is carrying out surface-based testing at a site at Yucca Mountain, Nevada, as part of a site-characterization program to determine its suitability for a radioactive waste repository. The DOE plans to begin construction of an underground exploratory studies facility using tunnel boring machines in March 1994. Preparation of the tunnel entrance and construction of support facilities for tunnel boring are presently under way at the site.

The selection of Yucca Mountain, Nevada, evolved from a series of scientific, budgetary, and political considerations. In 1982, after the DOE and its predecessor agencies had tried for more than a decade to find a potential repository site, Congress passed the Nuclear Waste Policy Act, which established a process for evaluating sites for two repositories. A number of potential sites were being studied in both the eastern and western United States when the Secretary of Energy in 1986 deferred the search for a repository site in the East. Critics contend that because the majority of the nuclear reactors are located in the East, the decision to proceed with a repository in the West placed an unfair burden on that region, where sites in Nevada, Texas, and Washington were being evaluated. Finally, after considering a number of issues, including the expense associated with characterizing three sites, Congress amended the Nuclear Waste Policy Act in 1987, selecting Yucca Mountain, Nevada, as the sole site to be characterized for the possible development of the first high-level radioactive waste repository.

Yucca Mountain is located in southern Nevada, about 100 miles northwest of Las Vegas and adjacent to the Nevada Test Site. The DOE's 1988 baseline repository plan calls for the burial of spent fuel and high-level defense waste in a repository consisting of more than 100 miles of tunnels excavated in rock about 300 meters below the surface of the mountain but well above the water table (DOE 1988). The repository would be sealed approximately 50 years after initial waste emplacement.

Federal standards and regulations (some of which currently are under review) will serve as a basis for determining site suitability and for authorizing construction and licensing operation of the repository if the site proves suitable.

# Observations about the DOE's Program

During its detailed review of the DOE's program to manage the nation's civilian spent fuel and high-level defense wastes, the Board has made numerous technical recommendations in six previous reports. The following discussion, however, addresses three concerns the Board believes have major implications for the scientific and technical integrity of the program and for eventual program success.

## *Unrealistic Deadlines are Driving the Program*

*Observation 1: The DOE's civilian radioactive waste management program is being driven by unrealistic deadlines to begin federal acceptance of spent fuel from the utilities in 1998 and to commence repository operations in 2010. Repository development schedules do not reflect a realistic assessment of the technical requirements associated with the development of a first-of-a-kind geologic repository. Attempting to meet these unrealistic deadlines may force the DOE to make important technical decisions without first performing the appropriate technical and scientific analyses.*

*... unrealistic deadlines may force the DOE to make important technical decisions without first performing the appropriate technical and scientific analyses.*

### *The Current Schedule*

The 1982 Nuclear Waste Policy Act authorized the DOE to enter into contracts with the utilities for the acceptance, transport, and disposal of their spent fuel. According to the Act, federal acceptance of spent fuel for disposal in a repository was to begin by January 31, 1998. In January 1987, realizing that this deadline could not be met, the DOE changed the planned start-up date for repository operations to 2003 (DOE 1987), only to change it again two years later to 2010 (DOE 1989). The Board has examined similar programs in other countries, and the U.S. program is the only one the Board is aware of that has been given a *legislatively* mandated date to begin disposal of spent nuclear fuel (NWTRB December 1992).

Because a repository will not be available by 1998, the DOE has planned to site and construct a centralized interim storage facility to store commercial spent fuel until repository operations can begin. Since 1989, the Secretary of Energy's two primary goals for the program have been to (1) begin receiving spent fuel at a centralized interim storage facility in 1998 and (2) begin repository operations in 2010 (DOE 1989). Congress established the Office of the Nuclear Waste Negotiator in 1987. Since his appointment in 1990, the Negotiator has initiated a voluntary process to find a site for the storage facility. Although the Negotiator

has made some progress and a few interested parties have been identified, it appears that insufficient time remains to find a voluntary host site and construct an interim storage facility to begin spent fuel receipt by 1998.

On December 17, 1992, in a letter to Senator Bennett Johnston, Chairman of the Senate Committee on Energy and Natural Resources, then-Secretary of Energy James Watkins acknowledged that no voluntary site had been identified that would allow the DOE to meet the 1998 deadline and asked Congress to authorize and direct the DOE to select alternative candidate sites for interim storage of spent fuel at federal government sites. Considering initial reactions from potential host states, this option also may prove difficult to implement. It therefore appears unlikely that any centralized interim storage facility will be available to accept spent fuel from the utilities by 1998.

***There May Not Be Time to Complete Essential Testing***

*... given all of the necessary scientific, regulatory, and institutional activities ... it seems optimistic to assume that a spent fuel repository will be operating by 2010.*

The original 1998 date for repository operations had to be changed because it was not based on a realistic assessment of the technical requirements of the program, and, given all of the necessary scientific, regulatory, and institutional activities integral to repository development, it also seems optimistic to assume that a spent fuel repository will be operating by 2010. According to the DOE, to meet the 2010 goal it will be necessary to apply by 2001 to the Nuclear Regulatory Commission for authorization to construct the repository. However, there may not be time to complete essential technical activities before that date.

1. *Exploratory studies facility.* Before filing an application for authorization to construct a repository, it is necessary to demonstrate whether or not the site at Yucca Mountain is suitable for repository development. Suitability cannot be determined, however, until an underground exploratory studies facility is constructed at the site. Scientists will then have direct access to the complex underground geology at Yucca Mountain and can begin some of the testing necessary to evaluate site suitability and predict repository performance. The DOE plans to initiate underground tunneling in March 1994, but testing in the tunnels may not begin until 1996.

2. *Underground testing.* Long-term heating and other underground experiments are needed to provide critical information on the effects of heat from the waste (the thermal load) on the surrounding rocks. This information is crucial for determining site suitability and designing the repository system. The Board is concerned that, since the tests have not been initiated, *there may not be enough time* to complete them by the 2001 deadline. Several DOE contractors have

commented to the Board that some of this testing could require a decade or more. If testing at the repository level does not begin until 1996, only five years remain to collect the data on which to base important licensing and repository design decisions.

3. *Waste package design and development.* The waste package is a key component in the radioactive waste management system. The Board has emphasized the importance of adequately and dependably funding research and development of waste package designs (NWTRB November 1990, May 1991, December 1991, June 1992). Yet the DOE has reduced funding to this program during the last three years, thus delaying important research. Deciding which waste package design is most appropriate requires extensive testing of materials — gathering data on how a variety of materials will hold up over thousands of years under various underground conditions. Under the current schedule, sufficient time may not remain to perform this testing adequately.

*... technical activities ... have been postponed repeatedly during the last three years, and future delays cannot be ruled out.*

These and other technical activities crucial to gathering the information required to determine site suitability and to make repository design decisions needed for licensing the repository have been postponed repeatedly during the last three years, and future delays cannot be ruled out. As a result, there may not be enough time to do the testing and analyses necessary to support important technical decisions.

***Other Factors Could Impede Program Progress***

A number of other factors beyond the DOE's control also could contribute significantly to further delays in program progress and affect the current schedule.

1. *Funding uncertainties.* To meet its 2001 deadline, the DOE has said that it will need an average of approximately $600 million per year for the next seven years just for *site-characterization* activities.[2] The DOE has never submitted a request to Congress for funding at this level (GAO December 1992). Current funding for the entire program is approximately half this amount. Given ongoing concerns about the large federal budget deficit, it appears far from certain that the Administration will request, or Congress approve, such increases.[3]

2 Carl Gertz in a presentation to the Nuclear Waste Technical Review Board, January 5-6, 1993.

3 According to an attachment to a January 12, 1993, letter to Senator Bennett Johnston, the DOE recommended to the Office of Management and Budget that the Nuclear Waste Fund be taken off budget.

2. *Changes in radiation safety standards.* In the fall of 1992, Congress passed legislation establishing a three-year process for promulgating a revised radiation safety standard and for subsequently revising the Nuclear Regulatory Commission's current regulations and technical requirements for waste disposal (Congress 1992a). Changes in the current standard or in the Nuclear Regulatory Commission's requirements could affect test plans and also could require changes in the design of the waste package and the repository.

3. *Delays in the legislatively mandated process.* The Nuclear Waste Policy Act requires the program to meet a series of milestones prior to applying for construction authorization, including submission of a final environmental impact statement and subsequent approval of the site by Congress by 2001. However, given the history of opposition to the program in the state of Nevada and the general lack of public confidence in DOE decisions,[4] court challenges and procedural delays are quite likely.

*The DOE already seems to have made some important choices based on expediency without first performing a thorough technical analysis ...*

4. *Unforeseen problems.* There is no allowance in the current schedule for accommodating unforeseen technical uncertainties or institutional problems that inevitably arise during such first-of-a-kind projects.

Considering past delays and the potential for future delays, the Board seriously doubts that either the 2001 construction application deadline or the 2010 repository operation deadline can be met.

***Deadlines May Force Premature Technical Decisions***

The Board is especially concerned that attempting to meet current unrealistic deadlines may force the DOE to make important technical decisions without first performing the appropriate technical and scientific analyses. This could lead to mistakes, costly remediation, or licensing problems.

The DOE already seems to have made some important choices based on expediency without first performing a thorough technical analysis of the data or of possible alternatives. An example of this is the DOE's selection of a thermal-

4 See Flynn et al. 1992. In addition, the Secretary of Energy Advisory Board Task Force on Radioactive Waste Management was assigned the task of considering what additional steps the DOE could take to increase public trust and confidence in the DOE's civilian radioactive waste management program. Its draft report was completed in December 1992 (SEAB December 1992).

loading strategy for its baseline plan.[5] In its fifth report, the Board pointed out that there is not an adequate technical basis for the DOE's choice of a thermal-loading strategy. The baseline strategy is consistent with accomplishing two objectives. First, it would allow the DOE to quickly demonstrate a capability to dispose of spent fuel (by 2010) and, second, it would minimize the need for long-term spent fuel storage. Attempting to meet these goals seems to have led program management to select a single baseline thermal-loading strategy without first performing a thorough analysis of alternative, perhaps better, thermal-loading options.

Unrealistic deadlines also are forcing the DOE to undertake activities simultaneously that might better be conducted sequentially. For example, it appears that to meet the 2001 construction application deadline and the 2010 date for repository operation, the DOE has selected 25- to 30-ft tunnels for the exploratory studies facility. Although perhaps appropriate for a repository, they are much larger than the Board believes is necessary for testing for site suitability and performing site characterization (NWTRB December 1991, June 1992).

Excavating such large tunnels may only add to existing concerns that: (1) large investments of time and money are creating institutional momentum that inevitably will lead to the selection of Yucca Mountain regardless of its suitability and (2) with no alternative or back-up site, Yucca Mountain must become the repository. These perceptions tend to undermine the DOE's credibility, which already has suffered as a result of problems associated with the management of radioactive wastes at defense facilities.

***Summary***

*The Board ... fully supports the need for schedules with target dates and interim goals to measure program progress.*

The Board understands and fully supports the need for schedules with target dates and interim goals to measure program progress. However, keeping to the current unrealistic deadlines may force premature technical decisions before sufficient data can be gathered and analyses performed to support these decisions. This ultimately may undermine the technical validity of the program *and* delay program progress. It also may further undermine the program's credibility among the technical and lay communities.

The Board supports adopting the approaches of other countries it has visited, where efforts are focused on achieving *interim* technical milestones, and where schedules for repository operation are tentatively set based on a realistic assess-

5 The *thermal loading strategy* is a plan for achieving the desired temperatures within the repository over a chosen time period. To develop a strategy, a number of issues must be considered, such as ageing, waste package design, and repository size and design. (See NWTRB June 1992).

ment of program requirements. Most other countries visited by the Board have set goals for repository operation for 2020 or later. There could be many advantages associated with establishing a new, more flexible long-term schedule that incorporates *firm target dates for interim goals*, such as getting underground, determining site suitability, and completing essential testing. Because decisions made under pressure can lead to mistakes and costly remediation or potential licensing problems, adopting a more realistic schedule may actually speed *real* program progress over the long run.

## *The Program Needs an Integrated Waste Management Plan*

*Observation 2: Existing DOE plans for managing spent fuel and high-level waste are not well integrated and contain significant gaps. In developing its plans, the DOE has not considered sufficiently the interdependent nature of the system and subsystem components involved in the transport, storage, and disposal of radioactive waste. Consequently, some crucial decisions may be made without an adequate technical evaluation of their impacts on other system components.*

From the time it issued its first report in early 1990, the Board has recommended that the management of spent fuel and high-level waste be viewed as a system of interrelated components. Looking at the generation, storage, transport, and disposal of the waste as a system is essential for several reasons.

1. Decisions made about one component of the waste management system may significantly affect other components, and a choice made in isolation could foreclose alternatives that might later be shown to be better for the system as a whole.

*Looking at waste management as a system is the most efficient way to set priorities ...*

2. Making decisions without adequately assessing their systemwide consequences could jeopardize the licensing of the proposed repository.

3. Developing program plans based on a sound analysis of the system helps avoid errors that may require costly and time-consuming remediation.

4. Looking at waste management as a system is the most efficient way to set priorities, to determine the logical sequence of activities, to integrate the activities of various entities involved in the program, and to develop contingencies to deal with the many uncertainties associated with this first-of-a-kind program.

Important concerns related to the three main components of the waste management system — storage, transport, and disposal — are discussed below.

### *Interim Spent Fuel Storage*

*... substantial amounts of spent fuel will remain in storage at reactor sites for decades.*

The DOE's baseline plan for the interim storage of radioactive spent fuel requires constructing a centralized interim storage facility in time to begin accepting spent fuel from the utilities by January 31, 1998. Currently, there are approximately 25,000 metric tons of spent fuel stored at reactor sites around the country,[6] and this amount is being added to at the rate of about 2,000 metric tons per year. Under existing law, the capacity of the interim storage facility is limited to only 10,000 metric tons before repository operations begin. Therefore, even if such a centralized interim storage facility and a repository are constructed according to the DOE's schedule, substantial amounts of spent fuel will remain in storage at reactor sites for decades. The implications of extended interim storage have not been addressed in systems planning.

Safely storing spent fuel does not appear to present any serious technical problems. Spent fuel can continue to be stored at the reactor sites in the spent fuel pools (if capacity is available) or in dry casks, as is presently the case at some utilities.[7] The Nuclear Regulatory Commission has determined that spent fuel may be stored safely — wet or dry — for at least 100 years.[8] However, as spent fuel pools near capacity, some utilities have met with resistance in obtaining permits from state and local authorities to use dry cask storage, due in large part to lack of strong evidence that a repository will be available in the foreseeable future.

As discussed in the Board's sixth report, the need for extended interim storage for all of the spent fuel is anticipated in other countries visited by the Board and has been integrated into their waste management plans (NWTRB December 1992). Spent fuel and high-level waste in these countries will continue to be stored at a centralized facility or at reactor sites until final decisions are made about repository development. Because extended interim storage has not been planned for in this country, it is viewed by some as signifying a failure to meet program goals.

In addition to expanding pool and dry cask storage, some nuclear utilities, faced with the prospect of long-term on-site storage, have investigated multipurpose container concepts that could be used to store, transport, and, perhaps, to dispose of the spent fuel.[9] The DOE also is increasing its efforts to develop a

6 By 2030, approximately 87,000 metric tons of spent fuel will have accumulated.

7 Dry cask storage is being used by Virginia Power at its Surry Station, by Duke Power at Oconee, and by Carolina Power and Light at its Robinson Station.

8 This determination is set forth in the Nuclear Regulatory Commission regulation 10 CFR 51.

9 Such concepts have been assessed by others in the past, including the state of Tennessee in the mid-to-late 1980s.

multipurpose container. The state of Nevada has provided important and constructive technical comments on proposed multipurpose container concepts. And the Nuclear Regulatory Commission has been quite positive in its comments about the prospects of licensing such containers. The Board has long advocated the development of alternative container concepts, including the multipurpose container, and is encouraged by these recent developments.

### *Transport*

Spent fuel has been shipped routinely and safely for the past 40 years. However, transport to a repository involves more than shipping. It includes removing the spent fuel from storage at the reactors, loading it into the transport cask, loading and unloading it at points of origin and destination, storing it, and finally placing it in a repository. Once repository operations are under way, the number of annual shipments of spent fuel and high-level radioactive waste will increase dramatically from historic levels. And with the much higher levels of activity and the greater number of people involved, opportunities for human error and equipment failures will increase, and hazards not apparent in the past may become evident. Therefore, measures are needed that will enhance current DOE safety practices. Since its first report, the Board has continued to urge the DOE to incorporate the principles of system safety and human factors engineering into its program to enhance safety performance. The use of a multipurpose container also could help minimize handling and reduce risks associated with transporting radioactive spent fuel.

### *Disposal*

The *thermal-loading strategy* selected for the repository has implications for other components of the waste management system, including the ageing of the spent fuel and the design of both the waste package and the repository.[10] The DOE's baseline plan calls for the disposal of relatively young spent fuel to create above-boiling temperatures within the repository for 300 to 1,000 years, and below-boiling temperatures thereafter. It is not clear that this is the most desirable strategy. In its fifth report, the Board recommended a systematic evaluation of alternative thermal-loading strategies (NWTRB June 1992). Although the DOE

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10 Spent fuel assemblies produce substantial amounts of radioactivity and heat (thermal energy) after they are removed from the core of a nuclear reactor. The thermal output of spent fuel decreases significantly over time (especially during the first several decades). Storing spent fuel to reduce its thermal output before disposal (ageing) is one way of controlling or manipulating the thermal load of a repository.

has initiated some work in this area, a comprehensive and systematic analysis of alternative, and potentially better, thermal-loading strategies for the proposed Yucca Mountain site has not been completed. As a result, an adequate technical basis for the DOE's choice of a baseline thermal-loading strategy has not been established. Yet decisions tied to that choice are being or soon may be made about multipurpose container concepts and repository and waste package designs.

*... the Board believes an engineered barrier system that includes a robust, long-lived waste package should reduce overall uncertainties about the performance of a repository.*

The thermal-loading strategy also has implications for the *engineered barrier system.*[11] Federal licensing standards require the engineered barrier system to work together with the natural barriers to isolate radionuclides from the accessible environment for many thousands of years. Although engineered barriers may have shorter lifetimes than do natural geologic barriers, it will be possible to predict the performance of engineered barriers with greater confidence than is possible for natural barriers. For this reason, no matter where a repository is located and no matter what the geology of the site, the Board believes an engineered barrier system that includes a robust, long-lived waste package should reduce overall uncertainties about the performance of a repository. As indicated previously, the DOE has not given sufficient attention to waste package design.

Other aspects of waste disposal should be more thoroughly evaluated and addressed in a plan to manage *all* high-level radioactive waste. For example, since 1985, federal high-level defense waste disposal policy has been to commingle canisters of solidified high-level defense waste with containers of spent fuel in the same repository.[12] Current estimates of the number of defense waste canisters are very broad — ranging from 15,000 to more than 200,000 — resulting in a more complicated and difficult design process for the disposal system. Other high-level radioactive wastes, such as the Three Mile Island-2 core, spent naval reactor fuel, and other defense reactor spent fuel, will probably require disposal in a repository (NWTRB December 1992). The special problems posed by the disposal of *high-level defense wastes* and *other high-level wastes* should be evaluated and integrated into the DOE's plan.

Another issue that should be considered is how long the spent fuel should remain *retrievable* after it has been placed in the repository. Current indications are that the DOE intends to design the Yucca Mountain repository to meet the

11 The engineered barrier system (in contrast to the natural geologic barrier) is made up of the constructed, or engineered, components of a disposal system designed to prevent the release of radionuclides from the underground facility into the geohydrologic setting. It includes the thermal-loading strategy, repository design, waste form, waste containers, material placed over and around such containers, and backfill material.

12 President Ronald Reagan announced this decision in a memorandum to Secretary of Energy John Herrington, "Disposal of Defense Waste in a Commercial Repository," April 30, 1985.

*... the DOE should ... set priorities among the many scientific investigations being planned.*

50-year retrieval requirement.[13] However, a longer retrieval period for spent fuel may offer some advantages, such as being able to monitor waste package performance or recover spent fuel for economic reasons. There also are disadvantages, such as costs associated with monitoring and maintaining the repository. The pros and cons associated with long-term retrievability options should be analyzed thoroughly, before repository design decisions are made.

The same principles that are used to evaluate decisions related to the overall system also should be applied to the repository. *Performance assessment* is the primary tool being used to evaluate the safety of waste disposal at Yucca Mountain. It is used to compare predicted repository performance with health and safety standards. Since its first report, the Board has been urging the DOE to begin a process of iterative performance assessment, by which periodic evaluations point out those areas of investigation that need emphasis, to determine site suitability and to ensure safety. In 1992, the DOE completed its first iteration in the performance assessment of the proposed repository at Yucca Mountain. Although additional work may be needed to improve the level of sophistication, the DOE should use this and other similar studies to set priorities among the many scientific investigations being planned.

***Summary***

The Board has urged the DOE to conduct top-level, systemwide waste management trade-off studies and performance assessment studies while the program is still in its conceptual phase so that decisions made now do not preclude options that may later be shown to be preferable. The management and operations contractor, who was hired to provide program integration, has recently initiated some work in this area. However, as stated in its sixth report, the Board believes that the studies undertaken to date are seriously limited by a number of assumptions being made by the DOE. This will foreclose a serious evaluation of some potentially viable alternatives (NWTRB December 1992).

13 Nuclear Regulatory Commission regulation 10 CFR 60.111.

## *Program Management Needs Improvement*

*Observation 3: The large number of organizations involved in the U.S. program and the diffuse nature of its organizational structure create substantial challenges for program managers. As a result, management problems seem to be adversely affecting some critical technical aspects of the program.*

The civilian radioactive waste management program encompasses work undertaken by the DOE, its dozen or so private contractors, a number of national laboratories, and the U.S. Geological Survey, as well as many others. The number of people working on the program now totals almost 2,000 (roughly 200 DOE employees and 1,750 contractor employees).[14] The program's organizational structure is multilayered, and the entities are geographically dispersed. Responsibility for decision-making is shared among the program director and associate directors,[15] the management and operations contractor, other private contractors, subcontractors, national laboratories, and the U.S. Geological Survey. Consequently, responsibility for program decision-making seems to be diffuse.

*... lack of integration remains a major problem that contributes to inefficiencies in the program ...*

The large and unwieldy organizational structure of this DOE program also creates substantial integration problems. The management and operations contractor was hired in 1990 in an effort to consolidate and integrate program activities. However, the management and operations contractor is not being used effectively.[16] Thus, the Board believes that lack of integration remains a major problem that contributes to inefficiencies in the program, especially in the development of a well-integrated waste management plan. This remains a major concern to the Board because, as discussed in the previous section, the lack of a plan affects every aspect of the technical and scientific program.

Another area of Board concern is funding allocation decisions. For example, in fiscal year 1993, funding for overhead and infrastructure — according to the DOE, the basic costs necessary to keep the program operating — will account for approximately 56 percent of total funds for site characterization (Edison Electric

14 In communications with the DOE Office of Civilian Radioactive Waste Management, November 1992.

15 The program has had seven directors in ten years. Five of the seven served in the capacity of acting director.

16 Edison Electric Institute commented in a recent report that the management and operations contractor was being used as if it were "just another contractor." The suggestion was made to allow them to do the job they were hired to do. (Edison Electric Institute 1992).

*Allocating such a high proportion of funds to overhead and infrastructure ... may have contributed to delays in the initiation of underground excavation and in the development of a long-lived waste package.*

Institute 1992). Allocating such a high proportion of funds to overhead and infrastructure leaves limited funding for important testing and research and may have contributed to delays in the initiation of underground excavation and in the development of a long-lived waste package.

Other countries visited by the Board provide interesting alternatives to the U.S. program's organizational approach. For example, in some countries, a government-sponsored corporation or organization has been created to implement waste management programs. In addition, in most of the countries the Board has visited, spent fuel producers are responsible for safely managing nuclear waste — including, in most cases, planning, financing, and executing all research, interim storage, transportation, and disposal activities. There seems to be more financial and managerial accountability in these countries, and their programs appear to be managed more effectively than the program in the United States (NWTRB December 1992).

Alternatives to the current U.S. organizational and management approach were evaluated in two congressionally mandated studies in the mid-1980s (OTA 1985, Advisory Panel 1984). Since then, no detailed comparison of the U.S approach with alternative approaches has been undertaken. However, Secretary of Energy Hazel O'Leary, at her confirmation hearing in January, indicated that she might undertake an evaluation of the civilian radioactive waste management program. The Board believes that an independent review of the program's organizational structure would be needed and welcome part of that effort.

***Summary***

The Board believes that the effectiveness of program management and integration needs to be improved and that the program would benefit from a thorough independent review of its organizational structure. Reviewing the approaches being used in other countries could be useful in such a review.

# Board Recommendations

Ten years have passed since the enactment of the Nuclear Waste Policy Act of 1982. The Board has concluded from its review of the program that, although significant progress has been made in site characterization and the collection of data at Yucca Mountain, much more remains to be done. Critical interim milestones, such as constructing the underground exploratory studies facility and determining site suitability, have not yet been achieved. There may not be time to complete the testing and analyses necessary to make important repository and waste package design decisions before the 2001 construction application deadline, and circumstances beyond the DOE's control could make it impossible to meet the 2010 deadline for beginning repository operations. Furthermore, the program still lacks a well-integrated overall radioactive waste management plan.

In light of the high cost of the program and the many uncertainties surrounding program progress, it is not surprising to hear public debate escalate over the DOE's radioactive waste management program. In its draft report to then-Secretary of Energy Watkins on January 14, 1993, the Secretary of Energy Advisory Board's Task Force on Radioactive Waste Management recommended measures the DOE might take to strengthen public trust and confidence in the civilian radioactive waste management program. Although somewhat pessimistic about increasing public trust and confidence over the short term, the report does recognize that without a strong technical and scientific program that is based on sound technical analyses, the DOE has little chance of improving public confidence in its radioactive waste management program (SEAB December 1992).

Recent initiatives on the part of the DOE suggest that program managers sense a need for change. In December 1992, the DOE recognized the need to look at alternatives to finding a voluntary host for an interim storage facility. This could result in the serious consideration of a range of options for the interim storage of spent fuel. The DOE also recently announced several new initiatives, including efforts to develop a multipurpose container for the storage of spent fuel and plans to investigate modifications to the existing waste management strategy.[17]

In addition to these new proposals by the DOE, regulatory changes may come about. The federal standards and regulations to be used in siting, constructing, and licensing a repository will be reevaluated in the next few years through a process established in the Energy Policy Act of 1992. Problems with the standards and regulations have been discussed to varying degrees in previous Board reports. Standards and regulations were addressed in more detail in the National Academy of Sciences report *Rethinking High-Level Radioactive Waste Disposal* (NAS 1990).

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17 Letters dated December 17, 1992, and January 12, 1993, from the Secretary of Energy James Watkins to Senator Bennett Johnston.

*... any program review should be conducted concurrently with ongoing work at Yucca Mountain ...*

At her confirmation hearing in January, Secretary O'Leary suggested convening a broad-based group to review the waste management program. The Board supports Secretary O'Leary's suggestion and believes that as she assumes her duties and the 103rd Congress begins its work, a unique opportunity exists to review the program's current status, to evaluate new proposals, and to address concerns about and make needed improvements to the program. The Board believes any program review should be conducted concurrently with ongoing work at Yucca Mountain to ensure that current site-characterization activities continue.

The Nuclear Waste Technical Review Board hopes that the following recommendations will prove helpful to Congress and the Secretary of Energy as they make important decisions about the future direction of the civilian radioactive waste management program.

***Amend the Current Schedule***

The Board recommends a more flexible schedule for the development of this first-of-a-kind geologic repository. Such a schedule should contain realistic target dates for achieving important interim goals, such as getting underground, determining site suitability, and completing critical testing. The DOE should set testing and funding priorities to achieve these interim goals. Once some of the interim goals have been achieved, it should become easier to realistically predict long-term schedules for repository operation.

***Develop a Comprehensive Waste Management Plan***

The Board recommends that the DOE place a high priority on developing a comprehensive, well-integrated plan for the management of all spent fuel and high-level waste, including its storage, transport, and disposal. This plan should be based on a systematic assessment of the interdependent nature of the various waste management components. It should include an evaluation of the following:

- a range of options for accomplishing the long-term storage of *all* spent fuel;
- the development of a multipurpose container concept that will help minimize handling of the spent fuel;
- the incorporation of system safety and human factors engineering to enhance the safety performance of the total system;

- the relative trade-offs associated with choosing among the various alternative thermal-loading strategies;
- the potential contribution of engineered barriers, including a robust, long-lived waste package to reduce the uncertainties associated with the long-term performance of the repository;
- the potential impacts of various options for incorporating disposal of other types of wastes into the waste management system; and
- the desirability of maintaining retrievability of the spent fuel beyond the currently projected period of 50 years after initial emplacement.

***Review Program Organization and Management***

The Board recommends that an independent evaluation of the Office of Civilian Radioactive Waste Management's management and organizational structure be undertaken. Reviewing approaches used in other countries could be useful in such an evaluation.

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