UNITED STATES

NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUMMER MEETING

June 29 and 30, 1999

Beatty Community Center
200 A Avenue South
Beatty, Nevada 89003

REPOSITORY DESIGN AND THE SCIENTIFIC PROGRAM

<u>NWTRB BOARD MEMBERS PRESENT</u>

Dr. Jared L. Cohon, Chair
Dr. Daniel Bullen
Dr. Paul P. Craig
Dr. Priscilla P. Nelson
Dr. Richard R. Parizek
Dr. Alberto A. Sagüés
Dr. Jeffrey J. Wong
Mr. John W. Arendt
Dr. Normal L. Christensen
Dr. Debra S. Knopman
Dr. Donald Runnells

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P R O C E E D I N G S

8:00 a.m.

COHON: I'm delighted about seeing people up in the balcony. That's wonderful. Thank you all for being here.

My name is Jared Cohon. I'm the Chairman of the Nuclear Waste Technical Review Board. It's my pleasure to welcome you to this summer 1999 meeting of our Board. By way of background and as context, let me review a little history.

Congress enacted the Nuclear Waste Policy Act in 1982, which among other things created the Office of Civilian Radioactive Waste Management, or OCRWM, within the U. S. DOE. That law also charged OCRWM in part with developing repositories for the final disposal of the nation's spent nuclear fuel and high level radioactive waste from reprocessing.

Five years later, in 1987, Congress amended the 1982 law to focus OCRWM's activities on the characterization of a single candidate for a final disposal site, Yucca Mountain, which as you all know is about 15 miles east of here on the western edge of the Nevada Test Site.

In the same 1987 amendments Congress enacted the Nuclear Waste Technical Review Board as an independent federal agency for revising the technical validity of OCRWM's program. The Board is required to periodically furnish its findings, as well as its conclusions and recommendations, to

Congress and to the Secretary of DOE.

Secretary Richardson has indicated that the decision on Yucca Mountain, that is whether it is suitable for a repository, will be based on solid scientific and engineering practice, data and analysis.

Technical decisions affecting people, and in the final analysis they all do, must involve individual community, state and national views and values as to what is important. And they must be transparent to the public. Your views count. That is why the Board is so pleased to be here in Beatty.

Our Board meets as a full board two to four times a year. We feel so strongly about the importance of local public input that most of our meetings are held in Nevada, and at least one a year is held in a community close to Yucca Mountain.

Last year it was Amargosa Valley, before that it was Pahrump, and the year before that we were in Beatty. And we are pleased to return here. And let me on behalf of the Board say thank you to the people of Beatty for your hospitality and your welcome.

Of course as we all know, Beatty and Yucca Mountain are both located in Nye County. The county has a strong nuclear waste program. In fact the Board took advantage of our drive from Las Vegas yesterday to see two of the well sites that are part of the county's early warning drilling program.

And I want to thank Nick Stellavato, standing in the back, Tom Buqo, Parvis Martizer and their associates for standing out in the sun for many hours yesterday to show us the drill sites and to give us some background on the program.

We're very pleased that the county commissioner from the Beatty district, Jeff Taguchi, is here today. Jeff is a third generation Nevadan, a local businessman, and director of the Valley Electric Association. It's my pleasure to ask him to say a few words. Mr. Taguchi.

TAGUCHI: All you need this morning is to hear from another politician, is that right? You probably hear from them on a regular basis, since a lot of you go back and forth from Washington, D.C., like I do.

But on behalf of my four other colleagues on the Nye County commission, we'd like to welcome the Nuclear Waste Technical Review Board to Beatty. As you know, Beatty is one of the centralized areas where this project will take place.

Nye County as a whole has had a relationship with the federal government for a long time. And from Nye County's perspective--at least from our perspective that relationship has ranged both good and adversarial.

But as far as we're concerned about what goes on here, what goes on with Yucca Mountain, and what has been said that the determination of the facility will be based on scientific and engineering principles, Nye County and the federal government must have some sort of communication process, and I believe this is where this begins.

And so on behalf of Nye County commissioners, I appreciate your attendance here. What we do here today and throughout the meetings in the future are going to have a-- consequently effect not just next year, but in millennia to come. And so I appreciate your time, I appreciate your research, your opportunity to serve.

I appreciate our Nuclear Waste Repository Project Office headed up by Les Bradshaw, who today will be able to present to us--or at least in this particular meeting--some of the things that they've been doing in this type of partnership agreement and communication agreement.

And so with that I'll turn it back over to Jared. Jared, are you going to be leading this up this morning?

COHON: Going to try.

TAGUCHI: Thank you very much for your time, and appreciate your presence here today.

COHON: Thank you for those excellent remarks. If all of our politicians were so well spoken and brief the country would be a better place. Thank you, Commissioner Taguchi.

The President of the United States appoints the members of the Nuclear Waste Technical Review Board from a list of nominees submitted by the National Academy of Sciences. We are by law and design a highly multi-disciplinary group with areas of expertise covering all aspects of nuclear waste management.

In introducing the members of the Board to you, let me remind you that we all serve on the Board in a part time capacity. We all have day jobs, as it were, most of them full time or even more. In my case, I'm president of Carnegie Mellon University in Pittsburgh. My technical expertise is in environmental and water resources systems analysis.

John Arendt--John, if you could raise your hand so people can see you--usually we're easy to identify because we have suits and ties on. We try to blend in with the local environment here, so you wouldn't so easily pick us out.

John is a chemical engineer. He retired from Oak Ridge National Laboratory after several decades of distinguished service in the nation's nuclear programs. And he formed his own consulting company.

He specializes in many aspects of the nuclear fuel cycle, including standards and transportation. John chairs the Board's panel on the Waste Management System. He was appointed to the Board in 1995 and was reappointed by President Clinton to another four-year term just two weeks ago.

Daniel Bullen is professor of mechanical engineering at Iowa State University, where he also coordinates the nuclear engineering program. Dan's areas of expertise include nuclear waste management, performance assessment modeling, and materials science. He chairs our panel on performance assessment as well as our panel on the repository.

Norm Christensen is dean of the Nicholas School of Environment at Duke University. His areas of expertise include biology and ecology.

Paul Craig is professor emeritus at the University of California at Davis. He's a physicist by training and has special expertise in energy policy issues related to global environmental change.

Debra Knopman is director of the Center of Innovation and the Environment at the Progressive Policy Institute in Washington. She's a former deputy assistant secretary of the Department of Interior, and previous to that she was a scientist in the U. S. Geological Survey. Her area of expertise is groundwater hydrology, and she chairs our panel on site characterization.

Priscilla Nelson is program director in the Directorate of Engineering at the National Science Foundation. She is a former professor at the University of

Texas in Austin, and an expert in geotechnical.

Richard Parizek is professor of hydrologic sciences at Penn State University, and an expert in hydrogeology and environmental geology.

Don Runnells is professor emeritus in the Department of Geological Sciences at the University of Colorado at Boulder. He's also vice president at Shepherd Miller, Inc. His expertise is in geochemistry.

Alberto Sagüés is professor of materials engineering in the Department of Civil Engineering at the University of South Florida in Tampa. He's an expert on materials engineering and corrosion, with particular emphasis on concrete and its behavior under extreme conditions. Alberto was also reappointed to a four-year term by the President two weeks ago.

Jeff Wong is chief of the Human and Ecological Risk Division of the Department of Toxic Substances Control in the California Environmental Protection Agency in Sacramento. He's a pharmacologist and toxicologist with extensive experience in risk assessment and scientific team management.

Jeff chairs the Board's panel on environment, regulations and quality assurance. Like John and Alberto, Jeff also was recently reappointed to a four-year term on the Board by President Clinton.

That's our Board. We're delighted to be here.

Some of you also know our Board's wonderful staff, of which we're very proud, and to whom we're very thankful. They are arrayed attractively--more or less--along the wall for easy access. Let your imaginations do the rest.

I want to point out in particular Bill Barnard, executive director. Bill? And Mike Carroll, the Board's deputy executive director.

I also have to report to you something which I we could call bittersweet. One of our staffers, Russ McFarland, who's an expert in tunneling, geotechnics and other areas, will be attending his last meeting today, or this week.

Russ--raise your hand, Russ, everybody sees you--Russ retires at the end of this week after more than 10 years on our staff. I know he doesn't look it, but Russ had more than 40 years of experience in the field. While what Russ may be going forward to do may be happy--and we're sure it will be--it is sad for us.

We'll miss his competence, diligence, and without question the most extensive network of friends and associates both inside and outside the program. He has a wonderful sense of humor, which we will surely miss. It's the glue that holds us together.

I'm also pleased to note that with us today is Lake Barrett, the acting director of OCRWM, and you'll be hearing from him momentarily. And Russ Dyer, the project manager of

OCRWM's Yucca Mountain Site Characterization Office. Russ will also be speaking to us this morning.

With us in his new capacity for the first time is George Dials. George, will you--recognize--there is George--thank you, George--who for almost a month now has been vice president and general manager of TRW Environmental Safety Systems. This means that George is in charge of the management and operating contractor, the M&O, which supports DOE.

I'm happy to say that the Board and George are not strangers. We visited WIPP in March 1998 and George was DOE's person in charge of that project. George, we're delighted to welcome you to the project, a project that has many similarities with WIPP, but also many important differences. We wish you the best in your new capacity.

I'm also pleased to note that Dan Wilkins will be here if he's--oh, he made it. Do that again Dan, so everybody can see you. Thank you. He's also from TRW. He's in charge of those M&O activities that directly support activities in Nevada.

Since our January meeting the Board has issued two reports and two letters to OCRWM. One of the reports was our normal annual summary of Board findings, conclusions and recommendations for the past year, for 1998 in this case.

The other report was the Board's comments on the

Viability Assessment. In it we addressed the scientific and engineering work needed to address uncertainties in repository performance based on repository design in the VA. Copies of both reports and the letters to OCRWM are on our web site, and they're also available on the back table, somewhere around there, today.

We consider this meeting a very, very important one, both for the Board and for the program. It's also a very busy program. We have a lot in it and a lot that we have to cover. And let me admonish all speakers--except the chairman, of course--that you must be on time. And we're going to be aggressive, hopefully not rude, in keeping you to your time limits.

Now I'll also acknowledge up front the Board is the worst offender often through our questions and slowing down presentations. So be it. The purpose of this meeting is not only to inform the public, but for the Board to get out of it what it needs to form its positions. So as I said, we're going to be aggressive in keeping to the time.

As you know from our agenda, the meeting will cover more than a day and a half, through lunch time tomorrow--past lunch time tomorrow. Most of today we'll focus on repository design.

For the past year the M&O has been carrying out a thorough and exhaustive process to select a repository design to use from this point forward. Last month the M&O formally recommended a design choice to DOE. We understand DOE intends to make a decision within the next two weeks whether to accept, reject or accept with modifications, the recommended design.

The repository design decision is a crucial one for this project, and it's one the project simply can't postpone if it's going to stay to schedule. If any repository is built at Yucca Mountain, repository design will play a significant role in its short and long term performance, which is exactly why it's such an important decision, and why this meeting is so significant.

By law our Board is required to review the technical aspects of the Yucca Mountain program. Using information in the presentations we hear about repository design today, together with positions on repository design and scientific uncertainty the Board has taken over the past year or so, we will provide our input on the recommended design, and we will strive to do so in a direct and timely fashion--that is before the DOE makes a final decision on the M&O's recommended design.

After repository design, the meeting will move to updates on scientific investigations. Most of this will be tomorrow. As you know, it is not only DOE that conducts investigations. The State of Nevada and local counties, including Nye County, also carry on important scientific programs, as we noted previously.

The reports of scientific investigations tomorrow will include DOE presentations as well as presentations by representatives of both the State and Nye County on work they are doing to increase understanding of Yucca Mountain and its potential behavior as a repository.

Now I'd like to turn to the matter of public comment, about which I have a few things to say. This is very important to us and for this meeting in Beatty we have included many opportunities for public comment and participation and informal interaction.

As I said at the beginning, this is something the Board takes very seriously and something to which we're very sensitive. We're planning three public comment periods for the meeting itself: one at noon today, one at 5:00 today, and another at 2:30 tomorrow, near the end of the meeting. All of these are noted in the agenda that's been distributed.

Those wishing to comment during these public comment periods should sign the Public Comment Register, which is located at the check in table near the door in the back. Linda Hiatt and Linda Coultry--Lindas? Wave at me, both of you. Thank you. They'll be glad to help you if necessary.

I have to say depending on the number of people signing up, we may have to set time limits on individual remarks. But those of you who have participated in our meetings before I hope will agree that we are quite fair in that, and we let people have their say. We will do the same at this meeting.

As an additional opportunity for posing questions during the meeting, we're going to continue something that we tried out, and we think successfully, at our meeting in January in Las Vegas. You can submit written questions to either of the Lindas during the meeting.

We'll make every effort to ask these written questions either by the chair--whoever's chairing the meeting at that time will ask the question, and if that doesn't happen because time doesn't allow it to, then I will pose the written question during the public comment period. So please keep that mechanism in mind as well.

In addition you know we always welcome written comments in addition to oral ones. Those of you who prefer not to make oral comments or ask questions may choose the written route at any time. We especially encourage written comments when they're more extensive than our meeting allows.

I'd also like to encourage you to keep in mind the topics of the meetings. If your interest is in scientific investigations, we'd encourage you to save your question for tomorrow--if you're going to be here tomorrow. Obviously if today's your only opportunity, we'll welcome your comments on any topic.

Let me also point out to everybody, this meeting is on the record. Our colleagues against the wall here are recording this meeting, every word that's spoken, including public comments. And that's an important part of the record for us.

Also we have a microphone system--I hope you've noticed. It's very important that you speak into that not only so we can hear you in the room, but so that we can have your comments for the record.

With all of these opportunities for comment, we hope to hear from many members of the public. But if you think that's a lot, there's even more. I'm starting to sound like an infomercial.

This evening the Board and staff are hosting an informal gathering for the public with hot dogs, hamburgers, chips and soft drinks. I want to point out this is not funded by the government. This is our of our own pockets. We hope you'll come and join us. It'll be at the senior citizen center right next door from 7:00 to 8:00 this evening, and everybody's invited. Please do come.

Tomorrow morning at 7:00 in this room the Board members, and only the Board members--no staff--will be here for coffee and danish. We invite any members of the public who would like to, to join us just for informal discussion. There will be no record of that discussion and no record of the hot dogs and hamburgers tonight. This will be a bunch of people gathering to interact, to talk about problems and issues of common interest.

We also have another bonus, or rather I should DOE has one. And this is at government expense. Set up in the back room, if you go all the way to the back, there will be a display and demonstration of DOE's geographic information system, as well as their integrated site model.

Mark Tynan of DOE's Yucca Mountain Project will be back there to demonstrate this for you. They're both very interesting and very valuable for understanding the site and DOE's work there, as well as design.

Finally, I need to offer the all important disclaimer that you're all clear on the conduct of our meetings, and what you're hearing and the significance of what you hear. Our meetings are spontaneous by design. These are not scripted events.

Those of you who have attended our meetings before know that the Board members do not hesitate to speak their minds. And let me emphasize that is precisely what we are doing when we're speaking. When a member speaks, and that includes the chairman, that member's speaking for her or himself. We are not stating Board positions unless we indicate otherwise. When we speak we're speaking as individuals.

With those remarks, disclaimers, invitations, and everything else behind us, I'm now very pleased to introduce to you--again--Lake Barrett, acting director of OCRWM, who will give us an update. Lake?

BARRETT: Thank you Jerry, members of the Board, members of the lovely town of Beatty. I really appreciate the opportunity to get out of Washington and come to Beatty. I mean this is a much better quality of life here. So I am very envious of those of you who live in Beatty, relative to living around the Beltway.

What I would like to do is sort of quickly go over some of the highlights of what's happened since we addressed the Board last January. I believe copies of the written remarks have been supplied to the Board, so I will just summarize that for the sake of time.

First of all the 2000 budget, you asked me to address that. The administration asked for $409 million in the 2000 budget. So far we've had action in the Senate; there has been no action in the House of Representatives. We believe the House will probably act in mid-July and start their process.

Basically the Senate marked us for $355 million. That's $54 million less than our request; that's a substantial reduction. That includes--that $355 includes $4.7 million for scientific oversight by the State of Nevada, $5.4 for affected units of local government, which would include Nye County; as well as $3 million to conduct seismic excitation experiments at the University of Nevada, Reno's Earthquake Engineering Facility. This provides us $342 million for the program, which is a slight reduction from where we are today.

I should also note that the Senate included $15 million to our Office of Nuclear Energy Science and Technology for evaluating advanced waste treatment activities such as accelerated transmutation of waste.

Our fiscal 2000 budget request of $409 was based upon the viability assessment. We are currently reevaluating our activities, taking into account the advances in the repository reference design, which we'll be talking about in some significance later, to address what is the work we need to be doing in 2000 that most fits that.

The Board has expressed concern about the impacts of the budget cutbacks in completing the planned science and engineering activities. We very much share that concern with the Board. We are prioritizing the activities that we believe are most important for the information needed to support a Secretarial decision on whether to recommend this site to the President or not.

We will emphasize those science and engineering activities that most effectively reduce the level of uncertainty in the performance of the repository. Building on the momentum achieved for the last four years, our objective remains to develop the documentation to determine if the mountain is suitable for a Secretarial decision to the President in 2001; and then if it is determined to be suitable and recommended, move on to a license application. However, with the current budget restrictions we're going to have to adjust those schedules.

Legislation--there have been comprehensive bills on the management of spent fuel and high level wastes in the Congress. The House of Representatives Commerce Committee has approved HR45. That is awaiting action on the floor. We expect that there will be probably substantial changes to that bill before it voted on the floor.

The Senate Energy and Natural Resources Committee approved Senate Bill 608 on June 16. Both of the House and Senate bills allow implementation of Secretary Richardson's proposal to take title of spent fuel at commercial reactor sites.

Under this proposal the spent fuel would remain at the reactor sites, but the Department could assume operational or financial responsibility for the fuel. This could be implemented in several different ways, depending upon the unique situations at each contract holder at each reactor site.

In many aspects, the Senate bill is substantially different than the previous comprehensive bills, in that it would amend rather than replace the Nuclear Waste Policy Act of 1982, as amended. The bill would provide for the acceptance of spent fuel at the repository surface facilities, after the Nuclear Regulatory Commission would issue a construction authorization for a geologic repository.

The bills sets as a milestone December 31, 2006 for the Nuclear Regulatory Commission to decide whether to issue a construction authorization. The bill would repeal Section 801 of the Energy Policy Act of 1992 and vacate EPA's authority to set radiation protective standards for the Yucca Mountain site, and the bill would give that authority to the Nuclear Regulatory Commission.

Additionally the Senate bill would establish an Office of Nuclear Spent Fuel Research in our Office of Nuclear Energy, to study the treatment, recycling, disposal of spent fuel, especially reprocessing and accelerated transmutation.

Now I'd like to turn to the recent Board reports. We appreciate your recognition of the importance of our successful and timely completion of the viability assessment. We agree that the viability assessment was a useful tool for integrating our work and setting the priorities, and the interaction with the Board I believe made that a better product over the time.

We are pleased that the Board found that the testing and research plans in the viability assessment are generally consistent with what we proposed. But the viability assessment, as the Board knows, was more than just a preliminary assessment of this site. It demonstrated our ability to coherently assemble the scientific information collected over a 15-year period.

It demonstrated our ability to use that scientific information to produce a design that would be feasible, both technically and economically. Finally, it demonstrated our ability to evaluate the performance of a particular design with a reasonable degree of confidence, and to enhance and improve upon that design, as the focus of this meeting will demonstrate even more.

Now the Board clearly emphasized the need to evaluate alternatives to that design. We have now fulfilled the obligation to issue the viability assessment and using what we learned to guide the evolutionary design development process as we select the next generation design concepts that will be used for evaluating the suitability of the site and the basis for the license application.

The design concepts we are developing seek to balance the programmatic considerations of repository performance, demonstrability, cost and schedule, as well as broader policy issues with the flexibility with regard to the time of repository closure.

Selecting a time range for closure involves both technical and institutional issues related to repository performance, extended ventilation, monitoring, economics, and societal conditions at that time. We believe that an a priori specification of a particular time of closure at this stage in the program is not appropriate.

Additionally, if the repository design required a preclosure period of say a hundred years or more, licensing could be complicated by a necessity in demonstration of preclosure operational safety for such long periods of institutional stability.

The intent of our design efforts is to develop a concept that affords future generations the flexibility to choose how long a monitoring period is appropriate, ranging from shortly after completion of the loading to several hundred years into the future, if they so desire.

This flexibility affords future generations the choice of closing the repository in the most beneficial manner in time, balancing the technical and institutional situation at that time in the future.

Our design criteria would enable future generations to close the repository promptly after loading while still protecting the public health and safety and the environment, or allow a safe extended monitoring of the facility until they are satisfied that closure is the right thing to do, or if they develop another course of action due to advanced technologies, such as possibly accelerated transmutation of waste.

Your reports and other recent correspondence emphasize the importance of reducing the critical uncertainties in the repository performance, and highlighted the merits of a lower temperature design. We recognize the consideration of uncertainties is central in any evaluation of repository performance.

We also recognize that temperatures are an important aspect of those uncertainties. Our design evolution process considers these uncertainties and the potential to mitigate them with various design approaches.

Last January we discussed with you what we intended to do in evaluating our design alternatives and the contractor has basically completed that initial work. And we are in the process of evaluating that now.

The goal was to develop and evaluate a diverse range of conceptual repository designs that work well in the natural systems of Yucca Mountain, and to recommend the next generation of the design evolution.

The Board has long advocated a comprehensive evaluation of alternative waste package and repository designs. The timing of the evaluation allowed us to take full advantage of the knowledge gained in producing the viability assessment. One relevant criterion in the evaluation was how well the various design aspects that we studied would reduce the uncertainties.

The recommended repository concept can be characterized as a lower thermal loading design, although it is not the coolest design considered. As you will see later today, the design uses more intensive thermal management techniques than the viability assessment reference design.

These thermal management techniques include thermal blending of the fuel assemblies, closer spacing of the waste package, wider spacing of the emplacement drifts, and preclosure ventilation. The recommended design differs from the viability assessment reference design in a number of other aspects.

While using both the two-layer waste package, the recommended design places the corrosion resistant material on the outside, rather than the inside, to provide long term protection of the more corrosion susceptible structural material.

This is consistent with the concept the Board suggested we consider. The recommended design also adds more defense in depth, with a titanium drip shield covered by backfill to protect the waste packages from possible dripping water while they are still hot enough to be susceptible to localized corrosion.

Finally, the recommended design concept uses steel structural materials in the drifts instead of concrete. This change helps avoid the possible impacts of concrete on mobilization and movement of radionuclides.

The evaluation of the next phase recommended design concept against all the criteria will be discussed in more detail in presentations later today.

I would like to emphasize the operational flexibility offered by this design concept. The recommended design concept allows further modifications toward either a higher temperature or lower condition in the future. This flexibility will allow the scientific and engineering data gathered by the program throughout the site characterization, licensing, construction, operation and monitoring periods to influence the repository design or operation as warranted.

For example, a move toward a cooler temperature profile goal could be a matter of changing the operating mode to include a longer period or higher rate of preclosure ventilation. Conversely, higher temperatures could also be achieved if new information deemed that change desirable.

I agree with the Board that this evaluation process needs to be well founded, well documented, and transparent. It is important program and interested parties to develop a common understanding of design evolution process. The Department will consider the Board's input before we take final actions on the M&O's design recommendation for the next phase of the program.

In the interim, we have begun to use the lower thermal design concept in lieu of the viability assessment reference design for activities that are affected by this design characteristic. The most important activity now ongoing is the evaluation of the 2000 work based on the lower budget for FY2000.

The design concept will continue to evolve as the program progresses and the design aspects are optimized. There will be I'm sure discussion about what is the appropriate ventilation rate for the preclosure period in this meeting later today.

An example of the refinement that we're also now planning to add is photovoltaic solar power panels to provide some of the electricity for preclosure ventilation fan motors. The design considerations such as those are appropriate for long term power supplies, and important to better align the program with the broader societal and technological objectives for both the national and global environment.

Now turning to regulatory processes, both the EPA and NRC have been developing regulations for geologic disposal that are specific to Yucca Mountain in accordance with the Energy Policy Act of 1992. The NRC has issued its proposed rule, 10 CFR Part 63, for public comment, and are holding public meetings including one here in Beatty.

The Department strongly endorses the NRC's use of risk informed performance based licensing criteria for implementing a radiological protection standard. This approach places emphasis on requirements that give the highest attention to the issues of most importance to the protection of public health and safety.

The elimination of numerical subsystem performance objectives and siting criteria found in the generic regulations at 10 CFR 60 in favor of overall performance objections allows both the Department as the applicant, and the NRC as the regulator, to place emphasis on the key technical issues related to the protection of the public health and safety and the environment.

The EPA's draft site specific rule is in the Administration's review process, prior to the EPA's publication as a proposed rule for public comment. As it should be, the Department is involved in this process, providing technical and scientific information.

It would not be appropriate, however, for me to comment on the specifics in the EPA draft rule at this time. I can say that the interagency discussions are leading to clarifications of the specific provisions in the rule.

The Department's primary concern has been that the technical aspects of the rule should not only protect the public health and safety and the environment, but also be a fair test of the safety of a repository that is demonstrable in a rigorous licensing proceeding.

Now turning to the near term milestones, with completion of the viability assessment the program is now focused on the completion of the site characterization phase. We plan to publish the Yucca Mountain draft environmental impact statement for public comment this summer. This comprehensive document has been prepared in accordance with the Act as amended.

The draft EIS systematically analyzes the potential impacts from the construction, operation and monitoring, and closure of the repository under a range of implementing alternatives, as we described to the Board last summer.

The draft EIS also provides information on the potential environmental impacts from an alternative referred to as the no action alternative, under which there would be no development of a repository at Yucca Mountain.

The preparation of the draft environmental impact statement has been a major effort by the Department and its contractor team. Despite many obstacles, its completion will further affirm that the program remains focused on the achievement of the key milestones leading to the completion of site characterization.

Following the 13 public hearings and consideration of comments, we are scheduled to publish a final environmental impact statement next year. This summer we will also complete the road map for accelerated transmutation of waste as requested in the FY'99 appropriations act. This will be important for society to look at in the FY2000 budget on development of that advanced technology.

The program is now focused on working to determine if the Yucca Mountain site is suitable for Secretarial recommendation to the President in 2001. As part of that process we'll refine the repository safety strategy to reflect the design evolution that we'll be discussing here today.

We are continuing to gather and analyze relevant data, some of which you will hear about tomorrow. We will complete descriptions of the detailed process models that describe the system performance, and the abstraction of these models that are used in the performance assessment. We will generate another major iteration of the total system performance assessment package.

Using this information, we will prepare a comprehensive package for public review and comment, describing the scientific and technical aspects of a monitored geologic repository at Yucca Mountain, prior to any determination of site suitability and decision on the site recommendation.

We will then refine the process models and total system performance assessment as a basis for decision making. And input from the Board will be very helpful as we proceed along this path.

The program's work is now focused on the activities most important to developing that information. The viability assessment clarified the remaining work required and illuminated those technical issues that needed to be further addressed prior to these decisions. We have started this remaining work and have commenced assembling the information to support a national decision on geologic disposal at Yucca Mountain.

Before I close, I would also like to make an important announcement about our TRW M&O contract. We are approaching the end of the 10-year contract with TRW, which started in 1991 and expires in February of 2001.

Although there is never a good time to recompute a complex project such as this one, we have decided, consistent with departmental policy and congressional appropriation language, to recompute the M&O contract on schedule.

We are looking at the activities and products that must be conducted and produced beyond 2001, and will use this recompetition as an opportunity to adjust the contracting strategy to best achieve those milestones.

Also I was going to mention--but Jerry already did--George Dials joining us. This will be a major help to the program as we go forward, and it's a very important one to gather the scientific information that we have to determine if this site at Yucca Mountain is suitable or not

I would be pleased to take any questions from the Board or whatever.

COHON: Thank you, Lake. Board?

CHRISTENSEN: Christensen, Board. Lake, you--I realize you don't want to go into detail on the issue of the EPA standards, but you mentioned one thing that I just would like you to maybe expand on a little bit. And I'm not sure I got the full text.

Concerns about safety are obviously very important, but the issue--I think you said fair test of repository performance demonstrable and regulation proceedings. Could you maybe say a little bit more about that in terms of what that--what that concern is from DOE's standpoint, and relative to the development of the standard?

BARRETT: Well in--first of all, the standard is to address appropriate environmental protections and public health and safety, and that it will do. Now there is a lot of judgment in how you apply today's science and technology toward that.

There is a broad range of how that can be done, and what we're--one of the issues that we are wrestling with, that you don't want to establish a test that requires science and technology beyond what is available, such that any site--let's say the most perfect site there ever was, though there is no perfect site, all right--could not meet it, because it would require a science and technology that's beyond what is available.

So it is a balance there that has to be worked through; that for example you can't--it is impossible in any geologic setting to map down to cubic centimeter type sizes, you know, kilometers away.

So how this is done and how this is applied is an extremely important aspect that you don't want to a priori establish a requirement that no science and technology is available to deal with that would automatically eliminate any repository site from consideration.

COHON: Debra?

KNOPMAN: Knopman, Board. Lake, you made some comments about design flexibility as you move forward, and I'm wondering if you could elaborate a little bit more on your philosophy here about how a design may evolve through the next--presuming there are next several stages in the regulatory process.

It sounds to me like you're not wanting to set a-- you need to design to carry out your analyses but you're anticipating further change over time. That possibly could be significant in terms of thermal management and assumptions about how you're going to operate the repository.

BARRETT: Okay, what basically--design is never static. Design is always dynamic. It is always in my view getting better tomorrow than you are today. You always learn more as time goes on, we'll learn more about the natural systems as time goes on, and engineering and technological technology hopefully is always advancing as well.

So you have a reference floor, reference design, and the reference design is constantly changing and evolving that is as good as or better than what you currently have. And let me try to put up a viewgraph that might help a little.

This is a little time pictorial of how design has changed at Yucca Mountain over the last 15 years. Back in the--last 10 years. In the late '80s we were thin walled two centimeter stainless steel package alone. Then we moved, there's a lot of interaction with the Board, to a robust thick walled package. Then we evolved--that was in the early '90s, but we didn't have a thermal load.

Then we evolved to the viability assessment which had the boiling fronts coalescing. We learned about -- over that in the discussion here. We now have evolved to the lower thermal load were the boiling fronts do not coalesce; we've added the titanium, et cetera.

And we will now evolve this somewhat and discuss about what is the right ventilation, we can discuss--and I believe you will be later--as to how much heat is rejected as a function of time. For example, here's Dan McKenzie will be talking I believe later.

But you can start to look at--as a function of time you can reject a percentage of the heat. The VA design is down here. We picked up a mistake on the airplane. It's eight percent of the heat is rejected in the VA design. But basically is a function of ventilation time and ventilation rate, how much heat is rejected. All of these kinds of things can be studied and improved upon.

Now the main points will be suitability. We're coming very close to closing on the suitability design. Then we're going to evolve for the LA design depending on when the LA is. I suspect that the regulatory process will bring forth issues before the NRC. They always do at least in reactor plants, as that would go forward.

Right now the ventilation is maybe on the low side. We have four ventilation and exhaust ducts. We want to add basically solar power for long term power concerns, three megawatts, one of the largest solar power plants in the world, if we do this here.

So a lot of this will evolve as we go on. Also I think, you know, a lot of work in the tunnel--these kind of things. So I suspect there'll be--the licensing process will be another design phase. Then you go into construction, you learn things as you construct, and I think we learn things from the ongoing performance confirmation programs as well.

So it'll continue but it'll getting better than where we are--reduce the uncertainty as time goes on is what our intent is.

COHON: Last question from Dan Bullen.

BULLEN: Bullen, Board. Lake, there's a quick question. You said you were going to prioritize activities to reduce uncertainty and it was based on the VA design for your $409 million budget. But then in the next statement you said the schedule -- SR and LA because of the budgets.

The question I have for you is are there key pieces of information or key experiments or key analyses that need to be done that if you're not--if you don't have those done you will slip the schedule; and do you have any ideas what those might be?

BARRETT: Well if we end up getting basically the Senate marks around 355, there will be schedule slips. Our prioritization process is to do our best to hold and to assemble a package for the site recommendation that is technically complete and can be sustained through that process, and let the license application work slip--and let the license application slip; but let's try to see if we can hold the national decision--do we or don't we have a site.

What this translates to in real work, I'll give you an example of one. To do a license application you have to do a lot of safety work on the surface systems, you know, fuel handling, pools and this sort of thing for an NRC license.

What we're basically doing is bringing that work down to almost nothing and focusing on the postclosure issues that are essential to determine if you have a suitable site. So those are fairly big dollar decisions. They involve a lot of real people. But we're trying to focus on the postclosure. So that's an example.

And the license application date is very much in jeopardy and will probably have to slip.

COHON: Lake, thank you very much.

We turn now to a presentation from Russ Dyer, who's project manager of the Yucca Mountain Site Characterization Office. Lake's presentation went a little bit long, but we thought Russ wouldn't mind having a little time taken out of his--for his boss.

DYER: Let me see if I can get here. Can you see okay? Okay. Next slide please. Can you see okay in the back? Do we need to dim the lights? It's okay?

I'm going to follow Lake here and set the stage a little bit for most of what you'll hear the rest of today, talks about the engineering side, the license application design effort that we've just gone through. Tomorrow we'll talk about some of the science work that is going on and planned.

What I'd like to do today in my little talk is to set the context, which is the plan work for '99 and 2000, go through what we've done and what is on the table for us. Site recommendation decision process, the process that intend to go through, the products that come out--not the answer--but how the process works; and some of the points about the technical integration that's needed to support site recommendation and license application effort, what's needed in the way of design and science work, how they play back and forth. Next slide please.

First let's step back and look at the project milestones here. We've completed the viability assessment. The next things in front of us are the draft EIS next month, the final EIS in the summer of 2000, the site recommendation, the national decision we're shooting at in 2001. Then everything else is conditional depending on how this turns out. Next slide please.

If we look at the major products that have come out of the project in FY'99, of course the viability assessment in December '98 was a landmark effort. The technical basis report for the TSPA of the viability assessment also in '98 was a very large effort. The site description document came out in January of this year.

What we have in front of us for the remainder of '99 is the design alternatives activity and the selection of the design concept. We're in the process of doing that now. We intend to complete that in July of '99. And then finally putting the draft EIS on the street, again as I said, in July of '99. Next slide.

Now what's ahead of us? Well, the project is in transition. We are shifting from the focus on the viability assessment to focusing on the EIS and the site recommendation process.

We are putting together a comprehensive plan that will take us through the final EIS in 2000, and will provide sufficient information for defensible evaluation of suitability in 2001, and if suitable can support this national decision, the recommendation to the President, that DOE proceed with submitting a license application to the NRC for construction of a geologic repository in 2002.

A little bit later I'll come back and talk about what this defensible and sufficient information is. Next slide please.

Design selection, a lot of effort going on on that for the last several months. We've looked at alternatives and options. We are in the process of selecting a single design concept that we will carry through, as Lake said, into the site recommendation in the LA, recognizing that it's an evolutionary process.

The goal of the design concept is to support the assessments of preclosure and postclosure system performance, how does the whole system perform; to be integrated with and complement the natural barriers, and then to provide required defense in depth through multiple barriers, through inserting engineered barriers into the system. Next slide please.

Now in the VA volume 4 we identified principal factors of repository performance and prioritized our information needs. That was based on a concept for one part of a repository system, one concept from the engineered system, with a slightly different concept for an engineered system, and also the information that we learn in the intervening time, needed to go back and relook at those priorities and see if they made sense or if there were new things that needed to be put in. And we have done that, using the alternative design concepts and that information.

There are some additional factors important to performance related to the drip shield and the saturated zone, and we have noted some changes in the relative importance of some of the other factors. Next slide please.

If you remember the repository safety strategy, which has evolved over the years as design has evolved over the years, we still have the four key attributes of the repository safety strategy.

They're still the same, limited water contacting the waste package, a long waste package lifetime, low rate of radionuclide release, and a concentration reduction along flow paths. These remain the four key attributes of the repository safety strategy.

The reprioritization effort that we're going through now is going to be completed in time to support the FY2000 planning effort, which we're in the process of doing now. And we'll incorporate the selection that we made for the SR/LA design. Next slide.

Okay, what are some of our key design activities for next year, in FY2000? Well developing process models and information feeds to be used as the basis for TSPA abstractions, you'll hear a little more about process models later.

This is a relatively new construct. I think Mike Vogel talked to some of you the process models. I think Mark

Tynan will talk a little bit, I'll talk a little bit toward the end of my talk about process models. They roughly--there is a degree of similarity between our process models and the NRC's key technical information element.

So we will continue materials testing and analysis for waste package and waste form. We will have--continue the development and maintenance of the requirements for the systems of the monitored geologic repository, and of course develop the necessary design products to support the site recommendation.

Now what about scientific investigations for FY2000? We have testing in the ESF and the cross-drift. Some of it continuation of stuff we are starting this year, some of it will be brought on line in 2000. Continue to look at the bomb-pulse chlorine 36 validation effort and expand that to look at the tritium carbon 14 technesium.

We have bulkheaded off the cross-drift and of course alcove 7 in the ESF, we'll look at the ambient moisture distribution effects in there as a function of time. We will be starting some tests in the cross-drift--started some already, but there will be more tests in the cross-drift, looking at hydrologic and rock properties.

Toward the end of FY'00 we'll be able to get out to the Solitario Canyon fault and do some testing out there, looking at seepage and fracture matrix interaction tests in the ESF, and of course continuing the drift scale test in the ESF.

Hydrologic testing, a high priority issue is looking at the volcanic alluvial aquifer testing complex, probably coordinate and piggyback on the Nye County effort in this arena.

Now site characterization, site characterization formally ends when the Secretary decides whether or not to recommend to the President that he approve the site. That does not mean that testing, science, evaluation ends at that time. It means that those efforts that continue on fall under the umbrella of performance confirmation rather than site characterization.

Performance confirmation, which is testing beginning during site characterization--it may be seismic monitoring, for instance, which has an element of site characterization. At a certain point in time it becomes a site--or a performance confirmation effort.

This will continue until the repository closure. These tests, experiments, analysis will focus on evaluating the accuracy and adequacy of the information used to determine whether the NRC's postclosure performance objectives will be met.

We can also conduct research and development testing to confirm the adequacy of the design and to address any remaining uncertainties or concerns.

Now in next four or five slides we're going to talk about the site recommendation decision process. What I want to lay out is what we have in mind for the process leading to this national decision, some of the temporal elements and some of the contents elements of this process.

In November of '00--17 months from now--we intend to put out a site recommendation consideration report, and initiate a series of public--a public comment period and some hearings beginning in 11/00, follow that up with a revised report in April of '01, which accommodates the comments, criticisms that are received during the public comment period; and then provide the as the basis for the Secretary's decision in June of '01. Next slide please.

Now let me go back to this site recommendation consideration report, the vehicle that will be out on the street in November of '00. We see it as having essentially two volumes to it right now. Volume 1 is the technical basis, it's the summary of the technical information required under Section 114 of the Nuclear Waste Policy Act.

That includes a description of the proposed repository design and the waste form or packaging, a discussion of the data obtained in site characterization relating to the safety of the site, and then a summary of the total system performance assessment, the first one that's done for the site recommendation. Next slide.

Volume 2 is a suitability evaluation, a preliminary suitability evaluation based on this TSPA that is included in volume 1. It includes technical conclusions compared to the regulations that are in place at that time, it'll focus on the postclosure performance of a geologic repository at Yucca Mountain, and it'll give a preliminary preclosure safety evaluation of repository facilities using preliminary engineering specifications.

As Lake mentioned, the distinction between preclosure and postclosure, the SR would focus more on postclosure. There will need to be much more in the way of preclosure information developed for the license application. Next slide please.

Now the hearings, I talked about public hearings starting in November of '00, we're looking at a public comment period starting, a 60-day period from the middle of November through middle of January '01, about; public hearings in December at least two locations near the site, and those are the requirements laid out in Section 114 of the Nuclear Waste Policy Act.

The product for April of '01 which will accommodate comments from the public and will also accommodate a revision, an update in the total system performance assessment, will provide the basis for the suitability evaluation and provide--also include the findings relative to the siting guidelines will be in volume 2 of this report.

The decision of the Secretary in June of '01 is going to be based on information and this information is laid out in the Nuclear Waste Policy Act. The final EIS provides an information basis for--or a decision basis; the site recommendation report that we talked about, volumes 1 and 2; views and comments of the governor and legislature of any state--especially Nevada--responses from the Secretary of Energy; preliminary comments from the Nuclear Regulatory Commission on the sufficiency of information for inclusion in a license application--that includes site characterization analysis and the waste form proposal; and then other information the Secretary considers appropriate. This content is pretty well proscribed by the Nuclear Waste Policy Act.

Adequacy of information--at what point is information deemed to be adequate for evaluating compliance with regulatory requirements? Well this is a logical AM test. You've got to be able to demonstrate a defensible compliance position through transparent and traceable TSPA, corroborative site characterization data, a defensible demonstration, and the compliance arguments can pass credibility tests. And it's unlikely that new information will change conclusions about repository performance. Next slide.

Technical integration--site recommendation and the LA will require documentation which is defensible through the technical rigor, and it's defensible through the documentation of the processes used. We've been working very hard on this for a couple of years. We've done some self-assessments, identified some areas that need improvement and are working very aggressively on improving the traceability of documentation.

The process model reports that you'll hear about are one way to do this. Process model reports would be the top tier level report which are supported by a multitude of analysis and model reports which in turn feed these process model reports, which in turn are supported by all the qualified data, codes and models and other information that resides within the project. On the engineering side, the design side, the system description documents provide this traceability of documentation.

Developing this technical documentation using a controlled set of data and models will provide a defensible evaluation of compliance, and is a cornerstone of the effort that we have going forward both for the SR and the LA.

This is briefly a process model logic diagram for one of the process models. This happens to be the integrated site model, which I think is running on a machine in the back here. This is the process model. It's feeds are two--I'm sorry, three analysis and model reports. One is rock properties, one is a 3D min pet model analysis, and the geologic framework.

Here are the suite of information data sets such as hydrologic properties data, bore hole porosities, XRD mineral data--x-ray diffraction mineral data, the regional potentiometric surface, mapping, geologic data, surface, bore hole geophysics, stratigraphic information. All feed into these various analysis and model reports which in turn feed the process model, which in turn feeds the EIS, the site recommendation report, the license application and TSPA.

In one way the process model reports are the equivalent of the technical basis report that we put out to support the TSPA-VA. The TSPA report is the primary tool for integrating scientific and design information for postclosure performance, and the technical regulatory conclusions are supported with corroborative measurements and observations, natural and anthropogenic analogues and peer reviews and expert elicitations.

The system description documents I talk about are used to define the requirements of the repository design. They will provide a demonstration of compliance with the repository requirements on a system by system basis. And they form the basis for the description of the repository in the site recommendation report. They're also the basis for preliminary engineering specifications.

Okay, in summary, the work scheduled for the remainder of FY'99 and that planned for FY2000 is intended to produce a well documented site recommendation consideration report for public review in November 2000. This is a dynamic ongoing thing.

We literally evaluate month by month what our highest uncertainties are, what resources are available. And as we are able to do it, we shift or reprioritize funding to try to address those things that pop up to the top of the priority chart.

With that, let me open myself to questions.

COHON: Thank you very much, Russ. We will allow time for one very good question, otherwise we're going to move on.

Good, I'm glad you took the hint. We're going to move on because we're so eager to get into the design thing. Thank you, that was very good. There may be questions later on that relate to it.

With that I turn the meeting over now to Dan Bullen, who will chair this next phase of the meeting.

BULLEN: Thank you, Jerry, A couple of points of information here, and this is in keeping with our public comment period. I will be very rigorous in enforcing the time limits for the speakers and in limiting questions of

Board members, and we will have public comment at noon.

Now you'll notice on the agenda that it says at 12:20 we continue questions for 10 minutes until lunch. I think that's a little redundant. What I'd like to point out is that I would like to--if we have deferred questions, to bring them up at 2:55 after the second Jim Blink presentation on the topics of the EDAs and the LADS process.

Primarily because of that I want to keep everybody on schedule up until that point, and I'm going to probably admonish both the speakers and the Board members that we're going to limit our time. But hopefully at the 2:55 time period all of the speakers will still remain in the room, and so if we have any questions on any of the previous presentations on the LADS process and the EDA selection, we can do that.

Now as a little bit of an introduction, I want to reiterate that the Board understands that the design encompasses both the natural and the engineered systems. And in this next session we're going to focus on the engineered systems as a whole. But we do recognize the fact that these systems work in conjunction with--engineered systems work in conjunction with the natural systems to protect health and safety of the public.

And we are very interested in hearing both about the LADS process and the design selection, so without further ado I would like to introduce Paul Harrington, who's from the Yucca Mountain Site Characterization Office, to give us a LADS overview and the DOE requirement for LADS. Paul?

COHON: Paul, as you're getting settled--this is Cohon, Board--I'm going to just pose a question to Russ that comes from the public. It's relevant right at this moment--I think would be a good one.

First, let me just convey this observation on behalf of the person who wrote this. It's not a question. They note that the current schedule calls for public hearings on the site recommendation consideration report in a 60-day period that includes the major holiday season. That's a lot of information--it's a bad time, it's a short period. You might want to take that into account.

The question is you are designing a monitored geologic repository but you're making decision about geologic disposal at Yucca Mountain. Is there a contradiction here?

DYER: No, I don't think so. The term monitored geologic repository reflects the change that we made perhaps a year ago, year and a half ago, to allow flexibility to the repository concept and not preclude the options of a future generation to either determine to keep the repository open and monitor it or to decide to close it if they felt that there was an adequate level of confidence in their understanding of the performance of the system.

So the repository and the monitored geologic repository are both consistent with a disposal philosophy.

COHON: Thanks, Russ.

BULLEN: Bullen, Board, just one point of information before Paul begins. I've been informed that there is a compressor out in the air conditioning system, which is currently being serviced and/or replaced, and that the room may get a little bit warm but they're working on it to rejuvenate the cooling system, I guess is the way to put it. So if anyone is concerned, they're working on the process.

Paul.

HARRINGTON: Thank you. The previous discussions have actually covered much of the reasons for the LADS process. Primarily it was to address uncertainty, to see what sorts of designs we could come up with that would allow us to decrease those uncertainties.

We also need to recognize that there's an NRC component in this. They require in their rules for us that we evaluate performance of alternative designs. This was to provide a comprehensive assessment of various design alternative approaches that have been proposed over time and to give an even evaluation to them, though certainly what we have at this point in terms of the recommendation from the M&O is a concept that has to be further developed to support taking forward to a site recommendation.

In the previous discussions, last January we talked about design alternatives and design features. Some of that will come up today to sort of recapture that. Alternatives were fundamentally different approaches to a design solution, whereas design features were different tweaks to that. You could take a design feature and apply it to any of several different design approaches. So it's just a terminology refresher.

And we were not to be constrained simply by what we had for VA. This was to be a complete assessment of available design approaches, concepts that were on the table and others that would be created through the process.

Now the DOE requirements for this took the form primarily in the planning and control system sheets, the PAC sheets, where we tell the contractor what we want them do during the course of a fiscal year. So we can read through here.

M&O have a statement of work said that they were to develop an evaluation of characteristics for features and alternatives, and also the selection criteria for that evaluation. It also required establishment of a decision analysis methodology, and we'll get into that in more detail later.

The description of a deliverable required that that analysis be based upon "involving performance allocation associated with appropriate standards, defense in depth approach, repository safety strategy, and appropriate system enhancements." We wanted to be very comprehensive. It also required that the conclusions be reasonable, traceable, clearly stated when evaluated in the context of available information, standards and guidance.

As you know, this started last summer. We were to initially have had the Phase I workshop to assess the work that had been done on the design approaches, the design analyses and features in December. That did not happen. We were still developing the technical basis for that discussion in December. So the Department agreed to delay that Phase I workshop until January.

We also took the action to send the contractor a technical direction letter and included the DOE expectations for the LADS effort. That's captured on the next two pages here.   In there primarily we established the DOE led integration group. I think we talked a little bit about that in January. It was to provide guidance and resolve the technical issues that would come up during the course of the LADS effort.

We also determined that the DOE staff and management needed to be appropriately involved through the process so as not to get a product that was a surprise to us, that we would feel was misdirected. So we wanted the complete and high quality documentation through the workshops. We wanted the level of confidence of the rankings to be provided. We wanted to maintain design flexibility by focusing on concepts rather than trying to get into detailed design solutions.

So as you see the report, it's really much of a conceptual approach. We haven't tried to close on specific design features such as wall thicknesses, those sorts of things. That'll be developed between here and SR and for those things necessary, then for LA.

A new rationale for the selection of the items that were to be taken forward as enhanced design alternatives. That enhanced design alternative workshop process was held in May, I believe--April. We wanted an unbiased treatment of design alternatives and features, and should bias be unavoidable, we wanted to see how that was therefore treated; provide the evaluation process for evaluating the EDAs to come down to a recommendation from the contractor for the DOE evaluation.

We also talked in that letter about the format that this report was to take. As you know there are several approaches that we could have from a very rank ordered numerically structured approach, to one that simply provide relative merits between them.

We wanted to see the status of the qualification of the data, use conservative PA assumptions rather than expected values where we had limited data, clearly and concisely document all of the objectives, the guidance assumptions and methodology, and again to address the potential bias toward the VA design. There was concern that this might be nothing more than a rehash of the VA.

The schedule--the M&O was to provide the Rev. 00 of this report to the DOE on April 15, and they did that. The revision to that, Rev. 01, to incorporate the DOE review comments was to be provided May 28, and they made that. The DOE site project was to provide that as a level 2 deliverable to the program on May 28, but instead of doing that we opted to take that Rev. 01 and review it for proper incorporation of all of the comments that had been made in Rev. 00.

So as I wrote this--it's on the next page--project baseline changes will be done after submittal to RW and concurrence. So Rev. 00 came in on the April 15th and the Rev. 01 came in May 28.

As I wrote this a couple of weeks ago, we expected to have made the formal submittal to RW-1, but as we only closed on the comments last week and have decided to take this through the core of the plant or project operating and review board, it's not yet gone formally to RW-1. And after we finish gathering input on this design approach, then we'll make the decisions and proceed with completion of the change documentation.

So in summary, the LADS process was to provide us a well documented basis for narrowing the design options, it's got to be defensible and understandable. There may be many design solutions that could have come out of an approach like this. Whatever the design we end up selecting, we'll have to have an adequate complete technical basis to support the regulatory exercises for SR and LA.

Questions?

COHON: Thank you, Paul. Questions from the Board?

Ms. Knopman?

KNOPMAN: Knopman, Board. Just a point of clarification in this process, Paul. DOE asked the M&O to develop selection criteria, or was that somewhat iterative between DOE--

HARRINGTON: Oh--that really was iterative. In the original approach, the original guidance to the contractor in the PAC sheet, we defined that this should be a quantitative cost benefit exercise.

As we got into it and realized that that really was misdirection of what we were trying to do with this, we were trying at the conceptual stage to figure out relative merits between design approaches and assigning a merit value to one versus another in terms of evaluation criteria or other. It wasn't really appropriate to what we're trying to do, so yes, it was iterative.

BULLEN: Questions from the Board? Questions from the staff? Actually I have a question, but I think you're probably not the right person to ask because the technical direction that was given by DOE said to use conservative PA assumptions where limited exists instead of expected values.

I guess the question that I have is how do you know they're conservative assumptions if your given that direction, and maybe that's best answered by people in subsequent talks. But--

HARRINGTON: I would refer that to the PA folks, yeah.

BULLEN: Okay. Part of the problem that the TSPA peer review panel pointed out was you didn't know when you were conservative based on the models that were developed, and so it's kind of difficult to know you're doing the conservative assumptions if you don't know which is the conservative path. And that's the concern.

Oh, I got a very good suggestion. Any other questions from the Board or staff?

HARRINGTON: Rob Howard is at the microphone--

BULLEN: Going to answer my question about conservative assumptions? Rob Howard.

HOWARD: Rob Howard. Performance assessment, that's a good question, Dan. What we tried to do was document the assumptions and in several cases evaluate a range of values where we didn't have the data. A good example would be getters where the data we had was highly tentative on certain.

We evaluated a range of parameters and a range of scenarios depending on how long the getter material would last, what would be a reasonable value for Kds. We bounced that off of what was available in the literature. Did we get that in all cases? You're always going to ask the question how do you know what is that you don't know. And I'm always going to give you a shrug.

BULLEN: Okay, thanks Rob.

HARRINGTON: Thank you.

BULLEN: Seeing no more questions from the Board, I'm going to take some chairman's prerogative here in noting that our first talk after the break--since we're not quite there yet--and I will claim that the 10 minutes we're ahead or so is my 10 minutes that was from 10:20 to 10:30, so I'm going to preserve that.

But I would like to ask Dick Snell to do his overview of the LADS process from the M&O perspective, and then we'll take the break, and I will keep the break to 10 minutes. If that's okay with you, Dick, can we squeeze that in?

SNELL: Sure.

BULLEN: Thank you, Paul. So our next presentation is again an overview of the LADS process by Dick Snell from Fluor Daniel. And the multimedia is already ready, so this is great.

SNELL: Probably I can talk from here. I think it'll be easy enough. These are high level overhead comments on what we're doing with the LADS process, and you will hear the particulars--and I know you're interested in hearing the particulars. It's taking us a little while to get to the meat, if you will. But it's coming shortly.

But there are some points I'd like to make about where we are in the process and how we've done it. First of all it was mentioned that this is a recommendation to the DOE. We published a report, the LADS report that Paul mentioned. It is in the form of a recommendation. DOE has not yet adopted that recommendation. That's to come in the near term as was indicated.

A distinction I'd like to make is that we're involved in a conceptual design development process, and design is an evolution as was pointed out. We're not quite yet at what I would call an optimization process, and I'll try and give you an example of what I mean by that.

We're looking at a drip shield design. That's one of the elements in the enhanced design alternative number 2, the concept that's been recommended. And from a conceptual standpoint first of all we think we want a drip shield. Drip shield seems to add significantly to the performance, and that's indicated by performance assessment information and other performance parameters that we have. It's beneficial.

We think we know that it needs to be a good corrosion resistant material, so we've picked as a for instance, as an example, titanium. We think we don't want the material to be the same material as is used on the outside surface of the waste package, so that if there happens to be some inherent flaw or some common mode item which might cause a failure in a material, if we have the same material for a drip shield and the waste package, that would not be so good.

So we picked a different one, titanium rather than Alloy-22. We think we know about what shape it should take. It's free standing. It does not rest on the waste package. It rests on the surface, bottom surface of the placement drips.

Some of the things that I would put into the optimization process, we can vary the shape a little bit. We've selected two centimeters as the thickness, but we can change the thickness. It doesn't have to be a smooth surface. I doesn't have to be a corrugated surface. We might want ribs on it. Those sorts of questions remain to be developed.

So the design still has a good deal of flexibility and the optimization of some of those last things I mentioned will come later after everyone is a little more comfortable with the concept.

We went to a set of five enhanced design alternatives. You'll hear more about those, but I think we briefed you at the conclusion of the workshop in January. And at that time at the conclusion of the so-called Phase I workshop, we had come with eight enhanced design alternatives. Subsequently that was reduced to five.

The comment was made that there are probably unlimited design options available, but we picked five because it allows us to focus evaluations on a set of alternatives.

They all are subject to variation, but these five represent a wide range of temperature conditions, temperature being one of the important drivers on performance. And they also allow us to look at other things like accessibility to the repository, choices of materials, and so forth. So those five became kind of a frame of reference for conducting the subsequent work which you'll hear about.

The alternatives all have operational concepts which remain flexible and subject to further development, again, as we go forward with evolution of the design and optimization, how long you remain open--these things have been discussed, do you ventilate and to what extent do you ventilate--those things are still available to us in terms of improving the performance on any selection that we make.

Some of the presentations you will hear following are some brief, very brief I would say, descriptions of the five enhanced design alternatives. There will be a description of the evaluation process itself, picking up in January--because you heard about the part prior to that. We don't want to spend time on it.

But from January on to the present time you will hear about the process we used, a fairly substantial discussion on how we chose to address uncertainties in going through the evaluation process, and then some discussion about what path we take as we go forward from here.

The last sheet in this brief handout is a chart that shows the process that we've used. I'm not going to talk through that. You can read it for yourself. But the bottom half of the chart is the Phase II and it shows the major steps that we have gone through to get us to this point today.

And that's really all I wanted to say at this point. We'll turn it over to subsequent speakers.

BULLEN: Thank you, Dick. Questions from the Board?

Wow. Questions from the staff? Okay, I'm going to exercise chairman's prerogative here and set a 10-minute break from 10:30 to 10:40, and I have the official watch.

And everybody back here in 10 minutes and we're going to dive into the second part of the session which is the EDAs.

(Whereupon a break was taken.)

BULLEN: Now we're actually getting to the Where's The Beef question. This is our presentation on the enhanced design alternatives, and we're going to begin with a presentation by Bob Dulin from Duke Engineering and Services on the assumptions and summary descriptions of the EDAs.

Bob?

DULIN: My task this morning is to tell you what we came up with in terms of the enhanced design alternatives. I'm going to describe those five enhanced design alternatives that we did evaluate as part of the last process, tell you a little bit about how some of the features worked in those alternatives.

First I want to describe some of the common features that all of the enhanced design alternatives had in our evaluation. First of those is a drip shield Dick mentioned previously. We had a titanium drip shield that we assumed for each of these five designs. We wanted a long lived additional CRM so that we could have a defense in depth approach to our repository.

Second thing was we added--we decided to use carbon steel for the ground support and invert supports. We had--we listened to the key technical issue that the NRC had raised about concrete. Looking at their evaluation of concrete as an issue, we determined that we couldn't tell if concrete was good or bad, and the NRC didn't know either, based on what they had done.

But we determined that it would take us a long time, long scientific program, to even determine whether we could eliminate that uncertainty from our design. We already had a viable alternative in carbon steel as a ground support approach, so we decided that to eliminate that major uncertainty in our program we would go with the carbon steel approach and therefore wouldn't have to go through that program to determine the concrete issue.

We kept a common drift diameter for each of these five EDAs. The drift diameter is really set by the largest waste package that we have in the program, which is a 2 meter diameter. And so we kept that, and used that as a common drift diameter for each of our five EDAs.

We used a preclosure ventilation approach for our EDAs. We assumed--when we looked at the requirements we went to this line loading for a temperature modulator in the drifts, and to do that you have to provide additional cooling in those drifts in that preclosure period. Also it allows us to take off a significant quantity of the integrated heat that's delivered from the waste packages. So we went to this preclosure ventilation.

We made some initial assumptions in our evaluation about how much of the preclosure heat we could remove. Initial assumption was that we were going to be able to get about 50 percent of that heat out.

You saw I think a previous graph that Dan McKenzie had prepared which talked about the amount of heat that's rejected over periods of time and with certain rates of ventilation. You could take one of those figures at about 50 years and about 10 cubic meters per second, you can get about two thirds of the heat out of the repository, and so we think we're in pretty good shape with our initial assumptions. Seventy thousand metric tons of heavy metal was used as our basis for the emplacement, and that's the legal limit for the amount of material we can emplace.

And then as I said we had already decided to use steel for our invert material and our ground support, but we decided to use a granular ballast in the bottom of that emplacement drift also in conjunction with that steel invert. So those are some of the common features that all of the EDAs had.

What varies amongst these EDAs? Probably the most significant features are thermal goals. We go from a repository with about 45 AML, a very--that keeps the waste packages still above boiling, but keeps the drift wall below boiling for all times in the future, to a repository that has--could have a significant thermal effect for thousands of years. So we have a wide span in our thermal goals that we looked at.

Two of our designs use backfill and three do not. We did not use--look at backfill or no backfill in each of these designs. We have two that we picked with backfill. Waste package materials, we use three different configurations for waste package materials. Most of them used a configuration which places the CRM on the outside, C-22, A-22 layer on the outside and a stainless steel on the inside. But we did have a couple of other variations that I'll quickly go through.

We did--if you look at the viability assessment design, the viability assessment design already uses a thermal blending approach, although very limited, because it limits the maximum waste package heat output to 18 kilowatts. What we have here is thermal blending in two ways then. We had some of the designs which still maintain the 18 kilowatt limit and then we had other designs which limited the waste package heat output to an average which was 120 percent of the average of what we might see in the repository. So it's like 11.8 kilowatts with a maximum waste package. Again this is one of those knobs you can turn on the design.

Drift spacing in each of the designs, you'll see some variance. The smallest is 32 meter center to center for the emplacement drifts, and the widest is 81 meters. Again that's a product of the thermal goals that we were setting.

Waste package spacing, we wanted to go to the line load so that we could smooth out those temperatures along the drift, putting the waste packages very close together. We assume 10 centimeters and hope that Dan McKenzie will figure out a way to make that happen in the future.

EDA I which was our lowest temperature design, we really couldn't make the thermal goals that we wanted with that 10 centimeter spacing, so we had to spread those out to a three meter spacing between the packages. But still it's essentially a line load. It's must closer than it was in the viability assessment design.

And the location, four of these designs still use the same emplacement level that we had in the viability assessment design, although they take different areal amounts. But the fifth design, EDA V, uses a lower block, which is east of the Ghost Dance fault. It's about 70 meters lower than the upper block that we use for the rest of the emplacement.

Some of the constraints that we placed on these designs, we were looking at still maintaining our ability to keep spent fuel cladding as one of our principal barriers. And so one of the constraints on that is to at all times keep our clad temperature less than 350 degrees C. That's an imposed requirement.

Also we looked at the issue of personnel access to the drifts. When we briefed you in January about some of the EDAs that we were considering we had some ideas that were somewhat more radical. And personnel access is what drove us to some of those. We got clarification on what we needed for personnel access.

We decided it off-normal access and we set some limits on what we had to do, and unloading the drift is still one of the most viable ways to do that. WE don't really want to operate in a high radiation environment at any time in the future, so unloading the drifts is still the primary way we would do that.

But we also looked to see if we could place shielding on these designs so that we could in certain limits be able to access these with personnel to do certain things, and we were able to do that, and so these designs look a lot more alike from that respect now we've eliminated some of that issue.

The last constraint we placed on ourselves was being able to close the repository as early as 50 years. Again this is a limiting design constraint. We used it because we know that there is a period of performance confirmation required.

We coupled it with the end of the ventilation, the active ventilation that we put in, and the placement of any backfill and drip shields that we've had in the designs. So we used that as a design constraint, and this is the earliest we could possibly place this material. And then we have plenty of options about what may happen in the future.

Let me just look briefly at these EDAs. I have some viewgraphs that show the areas that are involved with these. These are the site layouts for each of those EDAs.

EDA I uses the most area of the repository because we have to go to a small waste package size to limit the heat output of that waste package for this particular design. We had a goal to maintain the drift wall temperature at all times less than boiling, so to do that you have to lower the waste package size which increases the number of waste packages about 50 percent. We're blending on addition to that, so that heat output got down to about 6.7 as our maximum kW output.

Again we had to have three meter spacing between each of those waste packages. The drift spacing we set at about 43 meters. It required 132 kilometers of emplacement drift, which as you'll see when compared to the other EDAs is significantly more. But those are the--that's the basics. This is the coolest design we considered for the EDAs.

The EDA II layout--let me just stand on this side--again it uses the larger waste package size 21 PWR size. We use thermal blending to limit the heat output to about 11.8 kW. We spread the waste package drifts out, the emplacement drifts out to 81 meters center to center in order that we might have a large distance between those drifts that would be non-boiling.

We have--we know there are some specific goals there, but our real--putting those into what we actually did, we tried to limit that thermal output from those waste packages and do the other tweaks to our thermal management approach so that most of that area between the drifts is actually non-boiling. We wanted a large area to provide potential flow pads to water that might actually be in that area. So this is our--that's the main intent of how we set up EDA II.

Again this number of waste packages as you see here is just about consistent with EDAs II through V. This one does use backfill at closure in addition to the drip shield, and has about 54 kilometers of emplacement drift, which is less than what the VA used for emplacement drift.

EDAs III actually had two variations. We actually varied the waste package here. We used the waste package that we had used as far as the materials for EDAs I and II, for EDA IIIa. We had the two centimeters of Alloy-22 covering the five centimeters of stainless steel.

We also had a variation where we looked at a different waste package, two centimeters of Alloy-22 over another one and a half centimeter of titanium, then over stainless steel, so a three-layer waste package--and evaluated that.

It uses about the same number of waste packages as I said, drift spacing, and it's 56 meters, which is just twice the VA spacing that we had, and requires--this is essentially in terms of layout requirements, that doubling of that drift spacing puts it in the same footprint as really we had for the VA design. So it's a variation on the VA design with line loading and changed waste package.

EDA IV uses the same layout. That major change to this design is a different waste package. It's a very thick carbon steel waste package, and if you're looking at a regulatory period that is 10,000 years, the 30 centimeters of carbon steel that we're talking about here gives us a very predictable life for corrosion of carbon steel. And so that is a limiting life, but it's a very predictable life for the 10,000 years. So again we use the same drift spacing, 56 meters, and basically again it's layout-wise very close to the VA except the drift spacing's doubled.

And the last one is EDA V. It's a more radical approach, I think. Jim might disagree, but it uses a large waste package, but we put those at a drift spacing of 32 meters and line loaded it, ventilated it; lets us get a very high AML per acre, so we really have compressed the area of the repository.

In doing that we were able to fit it into the lower block of the repository because that has a little bit better hydrologic regime there than the upper block. But that's the changes made to EDA V. Same waste package that we used for EDAs I, II and IIIA in terms of the materials for the waste package. Again blended, no backfill, and it takes about 420 acres to actually squeeze this one together. Next slide.

So just in summary, we developed what we think are five viable alternative designs. All of them when we actually did performance analysis on them met the screening criteria that we had set up. All of them have considerable margin on that screening criteria. We used the drift shield; all of them therefore have considerable defense in depth. And we believe all of them could be closed as early as 50 years from the start of emplacement.

So I'm going to probably wait now and not ask questions. We'll get those after Kevin Coppersmith's time, is that right?

BULLEN: Actually since--Bullen, Board--since the chairman's prerogative is to allow questions whenever I decide, it's good that we've got you up here. And I'm going to ask my colleagues on the Board if they have any questions for Bob before he gets a chance to sit down, and then also reserve the right to ask Bob questions later too.

So any questions from the Board? Jerry?

COHON: Cohon, Board. Could you say some more about the potential importance of the closure period, whether it's 50 years or longer, for design? That is if you could have a longer closure period could you achieve lower temperatures with some of the designs we've seen here?

DULIN: Well of course the critical thing about the closure period is how old the fuel is that is in the repository. There's a fairly significant amount of decay that waste heat as we move out in time.

We're assuming for this particular waste stream--again this is--that's part of the box we're in, that we do have a particular waste stream assumed, that we have about 26 years on average for the fuel that's coming in. Then we have this 50 years, which varies of course depending on whether it's the first fuel in or the last fuel in for the waste that's there.

So you have a somewhat variable time there, and your fuel management is a key. So yes, if you wait longer to close you can achieve lower temperatures. If you can manage the fuel that's coming in, to a certain extent you can have that same kind of effect. So there are many things to vary there.

COHON: Yeah, and I'm just trying to get a sense of the potential significance. I know you've got to look at a particular design to tell us that, but I'm--just in a qualitative sense, if you had 75 years would that make a potentially big difference, or 100 years?

DULIN: Basically it's 25 years that you shift the aging curve. One of the keys for us is the--how old is the later fuel that comes in and how much do we have to work to achieve that heat output on those waste packages. If we get lots of very young fuel coming straight out of reactors, I think the youngest we could get is five years old.

That's very difficult for us to achieve, this 50 year closure, and maintain the loading on those waste packages. We may have to derate the waste packages, put fewer assemblies per waste package, and lower that heat output--which is much more expensive, of course, because it's a fairly expensive waste package and you want to put as much fuel in it as possible.

So those are the variables.

BULLEN: Debra Knopman.

KNOPMAN: This is Knopman, Board. This is a followup to that question because it has to do with operational flexibility. You don't say anything about surface storage or surface facilities, and that's another knob to turn of course for the agent.

Can you explain what you might--what options a larger surface storage operation might offer in terms of the loading, the thermal loading?

DULIN: Well, yeah, again there are many variables here. If we--let's take the extreme case. Let's take--say we take all the fuel in and store it all, and then we get to pick and choose exactly what we emplace. We take the fuel that we want to meet our characteristics underground, then we have infinite flexibility.

If we, instead of storing on the surface at the repository, what if we stored it at the reactor sites, got to choose the fuel that's coming from reactor sites. Then we'd have that kind of flexibility also. So yeah, it depends on how you do it, but there's many ways to achieve that same result.

I don't know if I answered your question.

KNOPMAN: Yeah, I think again what we're looking for is understanding what could be gained in terms of the design performance if you had that kind of--if you exercised that kind of flexibility in whatever combination or permutation you chose.

If you--what could be the best that you could achieve in terms of let's just say for EDA I if you were able to pick and choose your fuel and then would you be able to use less area? Would you be able to pack your packages in tighter?

These are the kinds of things that we're interested in knowing because it's an example of a constraint that affects your evaluation of these designs, that is sort of embedded deeply in the analysis. But we're trying to get out--that it's policy judgment about those operational questions, and that that needs to be brought to light I think.

DULIN: You know, without stepping back and analyzing too much your question, in the EDA I we have a significantly lower heat output on the waste package, 11.8 on EDA II and 6.7 on EDA I. So if you take a longer time period you can achieve--you can get smaller packages and get a smaller heat output. It's basically a matter of economics then and tradeoff--those kind of tradeoffs.

So you can put less fuel in, you can age the fuel, you can get less heat output; you can probably change the design once more and get them closer together. We hadn't analyzed that, so I can't get too close to that.

BULLEN: Richard Parizek.

PARIZEK: Yeah, Parizek, Board. The TSPA/VA '98 was an elaborate effort to take the standard design and show that it produced what looked like a safe result for some times in the future. Here in the five design alternatives in the summary EDA statement, it implies that maybe all of these five would also be safe?

DULIN: We think so. We think we--

PARIZEK: But it's hard to do that without going through that analysis, modeling analysis; and to what extent does the modeling analysis include--is included in this kind of conclusion?

DULIN: We did a TSPA analysis on each of these that didn't include the full range of uncertainties. That was part of our limits on the time we had to do. But with the understanding we have and the models we had in hand at the time to do that analysis, we believe that we adequately represented that all five of these would meet any proposed standard.

PARIZEK: So that is included--

DULIN: Yes.

PARIZEK: --that process. I should have known that perhaps, but it's good to hear that again.

DULIN: Rob could elaborate if you want to talk about that some more, but yes, TSPA folks did the analysis of performance on each of these five.

BULLEN: Alberto Sagüés?

SAGÜÉS: Yes, you mention that you're going to have in these design steel sets and also steel inverts. The amount of steel that would be used now, say for mineral tunnel, in these designs is it about the same or greater, smaller than that that was contemplated in the VA design?

DULIN: In the VA design we had assumed that one of every 10 of the emplacement drifts was going to be steel because of the monitoring, the geologic mapping requirements. We couldn't really map behind the concrete. So we assumed that one of every 10 of the emplacement drifts would be steel.

There's a lot more refinement to do about the ground support. You know, we haven't got final designs on ground support yet. And probably this invert is somewhat different from what Dan has even as the VA design. So for each individual drift my guess is that the quantity of steel is approximately the same as what we had in those one of every 10 drifts for VA, but we haven't really done the details yet.

SAGÜÉS: I see. What I'm trying to figure out is in the VA design you have so much steel per mile of tunnel, if you will, on account of the 10 centimeters of carbon steel that existed on the outside of the packages.

DULIN: Yes.

SAGÜÉS: Now if you make a computation of the total amount of steel that you would have in these designs as a result of the use of steel, say it's on steel inverts, and you compare that with the amount of steel that was used before in the VA design, do you have an idea which one would involve--

DULIN: --be significantly less than what was in the VA design. We had the carbon steel on the outside in the VA design. This has a stainless steel on the inside.

SAGÜÉS: Sure.

DULIN: But it's only five centimeters of stainless. There was 10 centimeters in the VA.

BULLEN: Bullen, Board. You miss the point of the question. He wants to know how much steel do you have in the steel sets compared to how much steel you had in the 10 centimeter barriers? Is it about the same amount? Is it more, is it less?

DULIN: I don't know the answer to the question. It's less I think, but I don't know for sure.

SAGÜÉS: That will be of interest because it would have to do with the total balance of iron in the repository. I wouldn't count the five centimeters of stainless--whatever iron is inside the stainless steel--inside the shells, just (inaudible) earlier (inaudible). Because all that steel in the sets--in the inverts is quite likely to undergo corrosion relatively early in the life of the repository. You're going to have to think what is going to happen with all that, of course.

DULIN: Right. I think we have significantly less, but I don't know that we've done a balance.

BULLEN: Paul Craig.

CRAIG: Craig, Board. Could you put figure 11 please? What I'm interested here is the relative flexibility of these different designs, and when I was looking at figure 11 I see EDA I and EDA II seem to be pretty much the same in terms of technical design except you cut the drift spacing by a factor of 2 almost.

And since you're going to drill the bores as you need them rather than doing them all at once, with EDA I you could put close together but then you could also omit using one of the bores and you could go to a spacing which is basically the same as EDA II.

So do you have number 11? Yeah, thank you. So just looking through there from the geological point of view, that seems to be the main difference. So what I'd like to ask you to do is to discuss the flexibility of EDA I relative to the flexibility of EDA II, and tell me if my guess that EDA I is more flexible than EDA II is correct. If not, why not?

DULIN: Well we looked at flexibility for a number of issues. One of those was the fact that at least in our EIS we had to discuss the issue of what happens if we're told by Congress to put more fuel in this repository than 70,000 tons.

If we have to put more in EDA I, when you get to larger and larger quantities, rapidly runs out of room and we have to go to areas that we haven't characterized; you know, if we get to the very large extent and we have any kind of problems with any kind of unexpected ground conditions. I think we evaluated that it barely makes it if you get the maximum extent that we could expect of both the defense fuel and the commercial fuel.

The other issue deals with the--our goal is the key, the 96 degree goal on the drift wall. So that's a more constraining goal, really, than having part of the wall boil.

CRAIG: So you could relax that easily. If you decided you wanted to go from EDA I to a higher loading you could simply put in a higher loading and then you'd have a higher wall temperature. So that seems to be a place where you've got plenty--you've got more flexibility with I than with II. Isn't that correct?

DULIN: Well that's one way to look at it. But we set the goals first and then evaluated flexibility within those goals rather than trying to vary the goals, flexibility on the goals. So the other part of the question is what happens if you want to go to a higher temperature and stay within those goals.

If you have EDA I it's more difficult. Basically you have to ventilate a lot longer for instance, or you have to have a lower thermal input to use the EDA I than you do for EDA II. So those--you know, we figured that EDA II could go either to a higher temperature or to a lower temperature, while EDA I would be more difficult.

CRAIG: So your view is II is more flexibility.

DULIN: Yes, sir. Perhaps somebody else may want to answer. That's a pretty key point on this whole discussion, so if somebody else wants to--from our group wants to discuss that, I'll be glad for them to do it.

BULLEN: Priscilla Nelson, Board.

NELSON: Nelson, Board. I'm not sure that this is a question, but I've been following the LADS process and I'm coming to the point here where I view this process predominantly as one really focused on waste packages. And with the design of a waste package, how can it be made to work? And there's certain oversight and back sight on the choice of criterion relative to what can work and what can't work for different waste packages and what is reasonable.

So you have the EDA II waste package and how can that be exercised in the context of the mountain? Or EDA III, IV, V, whatever--it's a very waste package oriented exercise. And the only one that's not quite so much that way is EDA I, because at that point one of the criteria becomes keeping the rock wall and all rock mass in effect less than boiling at all times.

And I wonder generally if the first major criterion in that exercise became how to make the mountain work best, rather than how to let the waste packages work best; if there might have been a different solution or different range of criteria.

So this is sort of a philosophical question and it's outside the bounds of the LADS process. But to me, and my perception right now, having followed it, is very strongly that this is a waste package oriented exercise and it's not a mountain oriented exercise.

DULIN: (inaudible)

NELSON: Don't have to answer.

DULIN: Kevin's going to talk about our process in just a minute, and talk about some of our evaluation criteria. But I can tell you that one of the key things for us as part of the LADS team was how can we reduce uncertainties and understand which uncertainties are the real keys to proving our case in the future and actually being successful when we get to a license application with this design.

So we were really focusing on those key drivers of uncertainty. Jim's going to talk about those and Ernie's going to talk about those later this morning. But those key uncertainties are things that led us to these designs. Those were what we focused on, both waste package and mountain.

NELSON: Nelson, Board. I'll be interested in that discussion because I think uncertainties are important there. But from the point of view of the mountain, I'm not convinced that this exercise is necessarily thrusted from letting the mountain work as well as it can, and remove the mountain's uncertainties.

BULLEN: Alberto Sagüés, Board.

SAGÜÉS: Okay, coming back to the package for a minute here, what are the maximum package temperatures that you would expect in EDA I and EDA II? I didn't see that kind of information in the tables.

DULIN: That's because they weren't goals, they weren't goals that we set for those five EDAs. We did calculate, and I don't have those in hand--waste package temperatures.

SPEAKER: (inaudible)

BULLEN: Jim, do you want to identify yourself too please?

BLINK: Jim Blink, M&O. It depends on what closure option you use for EDA II, and I'll cover those in my talk. The short answer is around the mid-90s for EDA I, and we have a range of possibilities ranging from just a little over 100 to about 240 for EDA II, depending on how we close it.

SAGÜÉS: Are you going to be giving time/temperature curves--

BLINK: Yes.

SAGÜÉS: --with your--okay.

BULLEN: Jerry Cohon.

COHON: Just to preview I guess what we'll be hearing, you just said that reducing uncertainties was the key. Which uncertainties were reduced and which designs did it?

DULIN: In all of our EDAs we chose to eliminate the concrete. That was the uncertainty that led us to a lot of work, and we really didn't know the outcome. So that was an uncertainty reduced there.

The thermal uncertainty that this Board raised and others have raised was a key driver on how we evaluated these five EDAs. So the thermal uncertainty goes to the mountain in terms of the boiling fronts to the mountain and what happens there, and it also goes to the material properties in the waste package.

We had in our VA design a waste package where the structural material by design deteriorated over a period of time, so we had an uncertainty because we had no backfill in that particular case. So we had an uncertainty about what happens in case of rock fall at long periods of time.

So what we chose as EDA II was evaluated based on the fact that we had backfill, we had a robust drip shield. We've eliminated some uncertainties there. The dual corrosion resistant material is the drip shield and the A-22 on the package now, so we have both of those; we have defense in depth with those different materials. They have different failure loads. So those are some of the ways we were looking at that.

COHON: Thank you.

BULLEN: Don Runnells.

RUNNELLS: Runnells, Board. Could you talk just a little bit more about the backfill, the rationale for having it in EDA II but having it absent in I, III and V?

DULIN: We were looking at backfill as one of the variables. When we set these five EDAs up we really did not know whether backfill was good or bad in terms of what we would want to do. We wanted to make sure we evaluated it both ways. So EDA I, we felt we wouldn't be able to achieve our--well, we did not choose to put it in EDA I at this time. We set this EDA up without it. We set EDA II up with it.

EDA III was most like the VA design, so we really are changing the waste package there in the thermal loading. EDA IV we felt had to have backfill. EDA V at the time we set it up we actually started off with this consideration of even doing rod consolidation and putting even more fuel in that package so it would be even hotter. Couldn't make that work; as we turned it out and tweaked all the knobs we couldn't make it work like we wanted to.

But we didn't think we could put backfill in there and sustain the fuel cladding. So there are a number of knobs to turn. But we did not look at putting backfill in or not putting backfill in in all five of those designs. We chose to put it in on those two.

Since we recommended the EDA II design we did a review to see whether we thought we ought to take the backfill out of EDA II, and looking at the uncertainties that backfill eliminates in terms of the final configuration, we decided that backfill was the right thing to do rather than take it out. That's our recommendation.

BULLEN: Bullen, Board. I've got a quick question since you mention fuel rod consolidation, and you mention the cladding temperature limits. As an EDA constraint you set the cladding temperature limits as 350 degrees C. You alluded to the fact that that was one of the limiting factors that changed your ranking or your design.

How would your ranking of these EDAs change and how would you approach have changed if you didn't have the 350 degree C temperature limit for clad?

DULIN: Again we started off with the 350 degrees as--

BULLEN: I know, I'm asking you something that you didn't do, and I see that. But if this constraint weren't there, how would you foresee this changing?

DULIN: One of the things you could do is you could backfill these designs earlier. Basically where you use backfill is on EDA II. The backfill causes a thermal spike in the cladding temperature, so 50 years becomes a constraint on EDA II, particularly because you have to maintain that 350 degrees. You could backfill earlier. That does create a blanket of heat.

As long as you still maintain an air path, you could conceivably have a blanket that kept heat inside near the waste package and still maintain a cool drift with ventilation. We haven't designed that.

BULLEN: Okay. Kind of to change gears here, but to follow up a little bit on what Alberto mentioned, I notice that four of the five designs have a waste package wall thickness that's significantly thinner than that of VA. And have you done a calculation of the radiation dose at the surface of the waste package, and could you comment on what that might be? What's the peak radiation dose expected for the designs I through V minus IV, I guess, because IV has a 30 centimeter package?

DULIN: I need some help--

BULLEN: Do you know of anyone--am I going to see that this afternoon, Jim? I guess that's a key question.

MCKENZIE: I'm Dan McKenzie with the M&O. Yeah, we looked at the thinner wall because that's a concern to us in the underground. We've got to handle the thing and doses are higher than they were in the VA.

I'm trying to remember, and I think the peak dose that we calculated to support the LADS was 200 to 300 r/hr from the surface of the package, which is little--not quite an order of magnitude higher than it was in the VA with 12 centimeters of material.

BULLEN: Thank you.

Actually there's a follow-on to this, and to allude to what Alberto mentioned, you're going to put steel sets in instead of concrete liner. And I have the radiolysis report that was used as a justification for not being concerned about the radiation effects except when you get to 200 to 300 r/hr and you look at the evaluation that Shoesmith made, he says that for C-4 and C-22 kind of families between 100 and 1000 r per hour dose rates basically have some concerns that you'd want to be looking at with respect to radiolysis.

But that's not the key issue here. The key issue is if you've got steel sets and you've got radiolysis in your field, you've got a potential for the steel sets to degrade even faster than Alberto's concern about just degrading in the near field. And I wondered if that analysis had been done. What effect would radiolysis have on the steel sets and did that drive your design selection?

I mean Paul Harrington mentioned that the thicknesses aren't set and that things could change, and I understand that. This is a constraint that you might want to be able to address right away, particularly since your own radiolysis study says that that may be an issue, in the range where you are right now.

DULIN: I don't believe we've addressed radiolysis of the steel sets in this conceptual design.

BULLEN: Okay, well that might be a suggestion as to something you might want to look at.

Any other questions--oh, Jim, you got some comments for me? Jim Blink.

BLINK: Jim Blink from the M&O. Remember that EDA II has backfill between the steel sets and the waste package, so I don't think you have to worry about the dose rate on the steel sets.

BULLEN: But not for 50 years. I guess the thing that comes to mind is the Climax Mine test, and I saw pictures of the heater tests that were put into Climax Mine, and you had the heaters and you had the waste. And the ones that heaters in them, the bore hole liners were just as nice as they day they went in; and the waste, as you put them in, they came out all rusty.

And so the concern that I have is that there is a radiolysis effect and it does effect the carbon steel, and it effects carbon steel even when it's hot. And so if you have a hot environment and you're putting the steel sets in there and you're producing nitric acid or whatever it is, the radiolysis products or bad actors if it's hydrogen peroxide, you've got to be concerned and you'd better evaluate it.

And particularly evaluate it in an open system in light of the fact that a lot of the results that Shoesmith shows in this report are for closed systems. So you've got to be very careful.

BLINK: In an open system where you've got the ventilation keeping things dry and you don't have aqueous films on the steel, I'm not sure that you have the other necessary constituents besides radiation--radiolysis.

BULLEN: Okay, convince me that you keep them dry too, by the way. Thanks, Jim, we'll talk about that a little bit later.

Any other questions from the Board to Bob Dulin here? Questions from the staff? Dan Metlay?

METLAY: Can you say anything about how your 50-year assumption for closure might change if the legislation that Lake Barrett talked about today is passed, particularly with respect to the Secretary Richardson's proposal to take title to the waste at reactor sites?

DULIN: I'll let Lake Barrett talk about that if he wants to.

BARRETT: I don't see any change nor connection.

METLAY: Would the fact that DOE had taken title to the waste at the site allow them greater flexibility to mix and match and choose the order of the fuel that could enter the repository? Would that make a difference?

BARRETT: It would make simplicity in the administrative aspects. It would just take some shipping, but I don't think that's a major concern, a major issue at all.

BULLEN: Thank you, Lake. Any other questions from the staff?

Well as I look at my official watch here I see I've almost eaten up all of my extra time. We're at the point right now where Kevin Coppersmith is going to give us a presentation on the EDA evaluation process, and we'll also have questions for Kevin and perhaps for Bob if there are any others after this presentation. Kevin?

COPPERSMITH: Okay, thank you. I'm going to talk about the process that was used to evaluate the enhanced design alternatives. This is a process that needs to be considered a decision problem. We're going from the viability assessment design to another design, and to make that design change there's decision processes involved throughout.

One of my themes is going to be as one of those who helped herd the design engineers over the last several months, but this process is in fact a conceptual design process that has components of decision making throughout.

One point I wanted to make, at the break I had a chance to talk with Jerry Cohon a little bit about the report he had. The Rev. 01 report is here for the Board. It's apparently I think in the boxes under the table, so we'll be sure to get that to you.

The discussion of the process that was followed I think is much clearer in the Rev. 01 report. Many of the questions that DOE asked us for clarification dealt with the process discussions. So hopefully that revision will help and I'll be speaking to basically what's contained within that revised report.

So what are the requirements for this decision process? What needs to be done, what are the components? And we set up this type of problem. First of all it has to be compatible with conceptual design process. That conceptual design process involves things like brainstorming, encouraging new ideas, moving people off of bias towards their preconceptions in previous design issues that they have grown very familiar with.

We also have in conceptual design usually those design concepts are centered around general design high level design requirements. In this case we migrated to temperature goals as the primary axis of diversity in these design concepts, but it's stated at very high levels in terms of the requirements. They're not specifics or specifications like detailed design.

We need to have a process that allows the designs to change and evolve. That's one of the things that I think is most significant about this process, is in fact you have the opportunity for--in light of objectives that have been stated to have the design evolve and continue to evolve, and it will evolve after today is over as well. So the process needs to be able to take snapshots using information you have available, but with the knowledge that there will be continual design evolvement.

We need to incorporate judgments as well as calculations. Even though as a group of engineers largely and scientists who like calculated values and models, in fact much of the conceptual design process is one of engineering judgment. This is a case where we have need to develop consensus of a team, LADS core team--as you remember discussions last--the January meeting--was responsible for most of the key decisions in the process.

There were also cases where we had meeting with M&O management and larger integrated group with DOE and M&O management. For someone who's a professional facilitator this provides ample opportunity for facilitation and consensus building across a wide range of groups.

It was noted as you saw on the requirements that Paul talked about, that we needed a consistent set of objectives early on, what do we want a repository to do, what things will we put value in in terms of the operations and performance of a repository system.

The advantage here of course is that we can actually modify the alternatives. This is not a case of a fixed alternative evaluation. It's a set of fixed criteria. We can modify, and did modify the alternatives to become more consistent with the criteria as we move forward. And they will in fact beyond these design concepts become progressively more consistent and go into what we call an optimization phase.

We need flexibility in this particular case to be able--for the M&O to be able to make a recommendation on the conceptual design that then the DOE evaluates, and they ultimately make a selection. So this type of process, this flexibility needed to be incorporated from the beginning. Next.

Well that decision problem then was tackled by this group, the LADS decision analysis team. These are the individuals involved and the roles that they played. I won't go into detail, but they span the range of those who are well versed in classic decision analysis techniques to people like Allin Cornell, a professor in civil engineering, Stanford, who provided--has gone through a lot of conceptual design activities and provided insights into that part of the methodology; and others like Pete Morris, who provided real time review as part of the LADS review team, as well as ongoing review of the process and the products developed.

All of this--I think the review process followed speaks again to the advantage of what I would call participatory review, where actual reviewers involved have meetings and hear what's going on and have a chance for mid-course corrections as you move through. Next.

So this team came up with a process that facilities this conceptual design activity and has the following attributed: objectives, which we call evaluation criteria, are identified early in the process. You remember our discussion of Phase I in January. We talked about the criteria that were developed to evaluate the design alternatives and design features.

A set of criteria very similar to those somewhat consolidated incorporating some other ideas were developed for the Phase II evaluation, enhanced design alternatives. The advantage for all those who are interested in things like value, focused thinking, is of course to develop those objectives up front. What is it that you want to do, what is it that you want to achieve early on, make those explicit. Then your design concepts can be developed around those set of objectives. It almost ensures success by identifying the objectives up front.

We had a series of workshops and interactions, maybe one of the longest workshops I've every facilitated, 10 solid days of interaction with breakout sessions and so on that occurred in early January--truly a brainstorming opportunity. After the first round of discussion some 28 designs were identified, and the number went down to eight by the end of the session.

This set the tone for the entire project, of interaction, meetings, workshops, and an opportunity to share ideas. That process of checks and balances is one that I think is very, from a process point of view, is very important. The project does well when engineers and scientists have a chance to get together and work out their differences.

A consensus decision process was identified as the way to go, with the LADS core team identified as the decision maker in the key decisions. That means that they were provided with and had to request information from all the design and science organizations throughout the project. They needed to integrate that information, to use that information as well as their own engineering judgment and experience to arrive at some of these concepts.

The documentation of course in the process has to provide sufficient documentation to understand what went on. For those that go through and read through the discussions in section 4, 5 and 6 of the report will see that we went through a process of actually chronologically going through each day of the workshop, what happened, try to bring the reader through, process reader through what happened.

I think for those who are interested more in the design that want to go to the end of the report and see what the design alternatives look like, but from a process point of view we tried to show what the core team had available to them at the time as they moved through in a chronological sense.

An important part of this activity was the development of the license application design integration group. Rick Craun talked about this at the January meeting. It's an integrating group that combines both DOE and M&O management representatives. It's an opportunity to on a weekly basis work through key issues and discuss possible key decisions that need to be made.

Some of those related to process I've identified here. First is the decision methodologies, the decision to use a less structured approach, one that's more consistent with conceptual design activities as opposed to a more quantitative numerical type approach was a decision made by the LADIG group that also would allow to preserve flexibilities for DOE in making it's final selection.

The Phase II evaluation criteria and their measures that I'll talk about here were discussed at length by the integrating group and were agreed upon. The desired product, one of the things I'll show is the ranking of the EDAs by criterion, individually as opposed to a full rolled-up multi-attribute utility analysis or a comparable type of rolled-up decision product was agreed upon as a product that was required.

And finally the M&O would be providing a documented recommendation upon which the DOE would look, would use that information as well as any other information they had available to arrive at a selection.

So these are the process steps. The first involves the evaluation of the DAs and DFs. We had a lot of discussion about that last time. The EDA development workshop in January that we also discussed whose goal was to arrive at a set of enhanced design alternatives for Phase II evaluation. That ended the middle of January.

And these two steps I'll talk a little bit about. The EDA evaluation process, the evaluation criteria that were developed, the workshop in March where we summarized the evaluations, got input from observers and others at that meeting.

And finally the comparative evaluations that were made, all of these evaluations are for each EDA itself against the criteria, and of course to be able to make a recommendation we need to compare the EDAs to each other. And the way that those were done is primarily using a ranking against each of the four evaluation criteria--I will show that; and finally making a recommendation in light of that ranking.

At the time of--when we last talked in January, eight candidate EDAs had been identified from the first workshop. Those were later reduced to five primarily on the basis of the issue of enhanced personnel access. Requirements were developed, at least high level requirements, for what type of access would be required. It was agreed that it would be for off-normal events only, and it looked like a temporary shielding and glass cooling would be able to accomplish that.

So some of the EDAs or components of the eight candidate EDAs that really dealt with this enhanced access part, the entrenched emplacement for example, did not become something we need to carry forward because the requirement for enhanced access was not so great.

We did though in going to the set of five we wanted to keep the full diversity of thermal goals or temperature goals for these designs. And that part, that aspect of diversity we tried to capture throughout the process and they are a diverse set of designs.

Now it's imaginable that you can have a hotter design than these, you can have cooler designs than these. This is a set of five EDAs that span a range that are workable, they all do very well in terms of expected performance. They all potentially could be carried forward, so this is not a case of looking for the needle in the haystack but finding the best design. These are all very good designs. They all have their pluses and minuses, and we'll talk about those.

During the time that this process was going on by the LADS team, the design engineers began about 7:30 the next morning after the first workshop to actually develop these designs. We had lead design engineers and all of the design organizations involved in the development of these five EDAs. And they really work.

What type of ventilation's needed, what type of drift spacing, what do you really need to do in terms of waste package, is it possible to put these things--what sort of configuration and spacing make them workable, at least at a conceptual design level--and that's what they spent their time doing.

The criteria in the meantime were developed by the LADS core team, were reviewed by and approved by the integrating group, and we went forward then with the evaluations. Now the evaluations were done as I said before for each EDA one by one against a set of criteria that I'll show next.

The purpose of developing these criteria is not so much to develop something that's going to have a quantitative numerical basis. This is a conceptual design activity. But we do want a set of objectives, a set of criteria that are consistent. And we talk about cost and we talk about licenseability, we talk about operations issues. We want to deal with all those consistently across the designs.

It's a step away though from highly quantitative analysis. Everything is put into a common utility function and is rolled up into that type of analysis. This is conceptual design. If some part of the design doesn't do well with those criteria, look at whether or not you can change it. If it doesn't do well relative to flexibility can it be changed? Is there a knob and aspect of the design that could be changed to make it more suited to that criterion. It's a different process than a fixed set of alternatives.

Each of the criteria have multiple subcriteria. These are evaluated on what we'd call natural or quantitative, like dollars or millirems per year, and constructed scale. Some of the constructed scales are 1 to 5 definition of the degree to which this design has defense in depth, for example.

They're not intended--the evaluation, the ratings are not intended to become part of a formal utility analysis, therefore they don't need all to be independent and mutually exclusive and collectively exhaustive, et cetera, et cetera. But they are--it is important that we lay out these objectives up front and use them consistently as we go through. Next.

What we're trying to do is to develop a consistent set of information and engineering judgments for each EDA. That process will then put us in a position to be able to rank the EDAs against each criterion. That's the important thing.

The process of getting at the ranking is one of simple pairwise comparison for dealing with--we're dealing with the issue of flexibility for example. We compare EDA I to EDA II relative to flexibility. We compare EDA I to EDA III relative to flexibility, et cetera. And we'd look at which one does better than the other in this simple pairwise comparison.

And in our case we're able in almost every case to make an evaluation of one doing better than the other in these pairwise comparisons. That allows you to arrive at a simple ranking which was one of the products that DOE requested and was agreed upon in the integrating group, is ranking the EDAs individually against the four primary criteria.

Numerical scores have no quantitative meaning. Everyone on the project who ever has a calculator, has ever been involved in any type of averaging, tends to want to sum numbers together and divide by the count and tell you this is a 2.35, that's a 2.783. We're not doing that. This process isn't one of either equal weights or unequal weighting. It's much more behavioral process of evaluation and conceptual design. So it's one where you have a set of objectives and now we're going to continue to evolve the design to make it more consistent. Next.

Here are the criteria, and I'll talk a little bit about these. The first is the screening criteria, and it basically is looking at the peak dose rate within 10,000 years, seeing whether or not it exceeds 25 millirem per year. I should point out that all the performance assessment evaluations and calculations that were done for this project are essentially single value, single estimate types of assessments.

For those of us who have been involved in uncertainty characterization for the inputs, this is not a process of looking at uncertainty. Uncertainty is characterized separately as another part of the process. Here we use central estimates first to make this assessment.

I should say though when looking at the five EDAs, they all are stellar in terms of 10,000 year performance. They're all many orders of magnitude below the 25 millirem per year limit.

The first criterion then is one of what we called licensing probability or safety, or just basically licensing demonstrability, how able are you to demonstrate the performance and other aspects. That deals with things like the time that the 25 millirem dose--is it out--is it just 11,000 years, just beyond the 10,000 year period, or is it 300,000 years. That's felt to be a difference there.

The level and timing of the peak dose at any time within a million years, to look at that and see how they compare. Again these criteria are being used primarily to differentiate between the designs, and some of them as you'll see end up being essentially comparable and they don't provide any discriminating power design to design. They're just intrinsically important.

Margin is basically defined as that difference between the 25 millirem per year and the 10,000 year dose rate. Degree of defense in depth, how many barriers are there, do they have common failure modes and so on. A very important one is on the uncertainties and postclosure performance and our ability to mitigate them.

The core team felt it was important in this evaluation to break down that uncertainty evaluation into three different time periods, uncertainties within the 10,000 year and the 10,000-100,000 years and then beyond 100,000 years.

This aspect of uncertainties deals not only with just uncertainties and can we model the performance. We all know that the present TSPA does not incorporate many aspects of the way nature really works. Conceptual models aren't always incorporated. Some of the coupled processes for example that are associated with higher temperatures and precipitation and changes in the fracture matrix interaction as a result of that, and so on.

Some of these issues are part of the uncertainty, whether or not they're modeled yet or properly parameterized yet is not the issue that the core team--they really tried to deal with uncertainty itself, where we really think it is, what the differences are among these designs.

Engineering acceptance, still for the issue of precedence, how can you demonstrate its postclosure performance, do you have standard designs that you can use for this and so on. There should be environmental considerations, are any designs unusual in the sense of larger environmental importance.

Then a set of issues related to construction, operations and maintenance. And I guess I won't read through all these here, but this is an issue that has to do with the operation--the operability--the overall hassle factor associated with individual designs, how different are they in terms of being able to emplace backfill versus not, for example; some of the handling logistics, do you need a very large shield to transport or make it very difficult, are there unusual aspects of the design, and so on.

Flexibility is a very important one, and this does take into account some of the issues that are more programmatic, policy level types of issues. But it was felt to be an important criterion to at least think about for these designs. And what we did for those is too look at alternatives, potential scenarios. There's nothing magic about these; these just define a range of things that are imaginable that we might need to consider.

For example, the issue of increased disposal capacity, going from 70,000 up to as much as 105,000 metric tons of heavy metal. How do the designs--how flexible are they in--relative to that potential increased capacity.

The preclosure period, right now with the assumption for all the EDAs is 50 years after start of emplacement will be the period where we close. But what about if we had to go earlier; for example, there's a possibility it might be 10 years after the completion of emplacement, or 100 years in the future, 300 years in the future. How will they do--how flexible are they relative to a change in that closure timing. The issue of the receipt of five-year-old spent fuel either early on or late on in the employment, are they flexible, is that a problem, how would they deal with it.

Design changes, depending on that the temperature goals are for the design, going from either a hot to a cold or cold to a hot, depending on where you are, and for some of the designs it's potentially going either way. The addition of having blending or not having blending or having backfill, not having backfill, these are design changes.

The assumption is that late in the design period, prior to construction but late in the design, a change had to be made, how would they respond to that; how easy would it be to modify that design. And the issue of unanticipated natural features or findings always comes in, how flexible would they be to be able to handle that, those type of findings.

And finally cost and schedule, does cost--and you'll see that they're in terms of total cost, in terms of net present value, the timing of those costs and so on comes into play. Next.

The comparative evaluation process is one where we begin to look at how the EDAs compare to each other. These were all evaluating them against the criterion one by one. And the primary purpose of those is to rank the EDAs against the four criteria so we can see relative flexibility, how do they rank; and finally to arrive at a recommended design, you finally have to reach that point where you meet the expectation of having a recommended design.

The ranking process was conducted by the LADS core team through a process of pairwise comparison like I mentioned before. But we're looking at each evaluation criterion individually, separately.

The source of information, it's often asked did you use the numbers of the scores that came out of your evaluation. The source of the information for the ranking process was much more than just the scores. It was actually the basis for that, the technical basis for the evaluation.

If something got a score of 2 in flexibility and another EDA got a score of 4 in flexibility, the issue is why, what drove those assessments, what are the important aspects there. That was a basis for the ranking, and what we have in the report in the discussion in section 6 is the discriminators--those issues that were most important for the ranking process, and a discussion of the thought process, the reasons for the ranking. So hopefully that'll provide a basis for that discussion.

Again I want to be sure that it's clear that the source of information, we allow engineers to use other experience they've had on other projects at other times, as well as the information provided by this project. Next.

This is the ranking against the criteria based on the pairwise comparison. These would be ranked first down to last so that the higher you are on the table the higher you are ranked. And the rank against the three--sorry, the four criteria, the licensing demonstrability/safety, flexibility, COM and cost.

And you can see for example how they do their discussion obviously in the report for how these rankings were arrived at. But for example, in terms of licenseability issues, EDA I ranks highest primarily because of the potential to have fewer uncertainties associated with postclosure performance, issues of coupled processes in the rock as well as issues related to localized corrosion of the C-22 outer waste package barrier come into play. They basically are eliminated or at least reduced through the process of the basic design itself. In EDA II likewise many issues there do very well.

It should be important though, on this one, is that when it comes to things like performance, the expected calculated performance, they all do very well, so the ability to use that as a strong discriminator doesn't work. You discriminate these five against some others that are crummy designs--we probably should have thrown in a crummy one just so we could show how poorly they could potentially perform. Next.

I've been in your spot many times, Dan. I know that we've got to be done by noon.

BULLEN: It's okay. I reserve the right to call you back, so that's not a problem.

COPPERSMITH: How do you get to the recommendation? Well one of the important aspects of a decision process is going through the process of identifying objectives, evaluating your alternatives against those objectives, and then develop--using what's called a value model to say which of your objectives are more important than the others.

We recognize those. Our decision team recognizes those; they're authors of papers that of course do that type of analysis. But the goal here was not one of imposing or developing a strict value model. It was one of leaving that part open and to look at how they do, how they evaluate, how they rank, and to leave the roll up process of one that potentially DOE could impose. We allow for more flexibility by doing that.

This process--what we did impose though is we looked for consistency. We felt at this point across the four criteria it was important that we have a design that ranked reasonably well against all four criteria as opposed to doing very well against one or two, but poorly in another.

Now that could be argued that that's a value model, and I would agree with that. But it's not a strictly imposed weighted value model or utility type model that we might expect.

It's possible for example that the DOE or other groups looking at this could arrive at a different conclusion, given their value on a particular aspect. If cost was your driver, for example, you might have a different conclusion. You wouldn't in this particular case, but let's say for example that licensing demonstrability is everything. That's a case where you could arrive at a different conclusion. But this is an aspect that's very important, that we try to look at consistency across the four criterion, arriving at our decision.

EDA II, based on that was judged to provide a reasonable balance between the licenseability issues, construction operations issues and cost and so on. Next.

Let me just briefly summarize the thought process that is used in arriving at EDA II as a recommended design. We look at many of the aspects related to--let me put this out--you have this in your viewgraph package. It'll be illegible from the back of the room.

But when we look at performance related factors, they all do very well. So in a sense they're not discriminators, they're intrinsically obviously very important for ability to use them to separate out one EDA from the other doesn't work--doesn't provide that information.

Terms of licensing, safety factors, the issue of our ability to demonstrate performance, EDAs I and II do the best, and particularly issues related to uncertainty in postclosure performance, couple processes and so on. EDA I does very well. EDA II we believe also does very well.

We have--when we look at waste package corrosion issues, rock temperatures, these cooler designs do very well in this aspect. Going to higher temperature designs, we get into issues of things working right, relative humidity, temperature, timing working out properly so that things, the waste package surface doesn't see aggressive conditions for an extended period of time.

Looking at construction, operations, maintenance issues, the--basically the EDAs II through V are very similar in terms of many of these aspects, number of waste packages, the length of emplacement drifts and so on. But there's an non-linearity as we go into EDA I, the increase in number of waste packages by 50 percent, 100 percent increase in length of emplacement drifts; and we get into operational issues, worker safety issues, associated with just more drifting, more waste packages, more handling that comes into play, again dealing with this particular issue.

On flexibility, when we deal with issues like the potential for increased capacity, we looked at the size that was required, would be required for the increased capacity. And we dealt with whether or not we'd have to move out of the characterized area. And EDA I is the only one that with increased capacity would have to go into an uncharacterized area in the region. So there is not--it does not have the flexibility in terms of the potential for increased capacity.

There's also--when we deal with the potential of change to a higher or a lower temperature, EDA II does very well here. Potentially we're able in EDA II to--if we decide to change the temperature goals from lows of EDA II to EDA I, we have the potential to have the flexibility to achieve those goals without major design changes.

For many of the other EDAs when we deal with a change in those temperature goals, it would require a major design change--changes in the drifting, changes in other configuration aspects. EDA II is particularly flexible there. EDA I does not do nearly as well in these areas.

And in terms of cost, again in terms of total cost, essentially EDA II through V are comparable, and EDA I is 20 to 25 percent higher. In terms of net present value again they're much more comparable, but a significant increase in EDA I on the cost side.

So the thought process was moving our way through this, arriving basically we're down, EDA I or II and EDA II basically tipping the scales in terms of its consistency across all four of our criteria. And that's how we arrived at EDA II. Final slide. Got a minute and a half. Next.

So in conclusion the decision process is compatible with conceptual design process, brainstorming, new ideas and providing maximum flexibility to DOE in their ultimate design selection.

We have evaluation criteria that reflect our objectives. Design concepts will continue to evolve. They evolved throughout this course of the process. We now go into refinement, optimization stage where the design evolution is expected as well

They were ranked according to each criterion. That's information that anyone has at this point to look at. And design concept was recommended based on consistency across all four criteria.

BULLEN: Thank you, Kevin. I'm going to exercise chairman's prerogative and ask Kevin to come back right after lunch, and we'll hold your questions until that time.

It is almost exactly noon, and I would like to turn this session over to our chairman, Chairman Cohon, for the public comment period. So Board members, just jot those questions down and immediately after lunch we'll ask Kevin to come back, and we'll also reserve the right to have him hang around to about 3:00 and ask more questions.

With that I'd like to turn it over to Jerry for public comment.

COHON: Thank you, Dan. Just to confirm what seems to be the case, we have at least four people signed up to comment, Sally Devlin, Judy Treichel, Martin Mifflin, and George Danko.

Two people put their name on this list and we can't tell whether they really want to comment or not, or whether they put their name here in error. David Howtzel and Scott Rogers, did either of you want to comment? Are you here?

Did you want to make a comment? Okay. Duly noted.

Ms. Devlin, you're up first.

DEVLIN: First of all, may I say thank you all for coming. And it's always a pleasure and this overflowing room is really a delight. I don't know how many of the public are here. Usually I'm the only one.

But there really--and I want everybody to get a piece of paper and pencil because you're going to have to write down what I ask for. Priscilla--you bet, thank you.

Okay, there has been an egregious deletion in your wonderful research program. And the reason I'm giving this dissertation is because there is a situation in Nye County that is untenable, and I feel that this Board, the NWTRB, is the only unit of government with the knowledge, the experience and the clout to solve our mutual problem.

In his introduction to Volume 1, Lake Barrett created new terminology. I called Washington; I have had no definition. But he used the term Assigned Uncertainty, and from what I understand this means that questions have to be answered given the context of the moment. And what I'm going to present to you is not of the moment; this is very serious.

Theses questions have to be decided and it will take many years. What we have in Nye County, and for those of you who don't know Nye County, we are the largest county in Nevada, we're the third largest in the world. And what we don't have in this concept of Yucca Mountain is the danger to the health and welfare of the workers and the people involved in it.

As of today the Tonopah Hospital will be closed and privatized. Pahrump has been paying $1.2 million to support it over the years, and no more. As you see on the hill, there is a little health facility here in Beatty, there is a little health facility in Amargosa; there is nothing in Crystal Johnnie. I don't know what they have in Goldfield.

But there will be no health facilities. There are no hospitals. There is no emergency preparedness, and we have no community groups to investigate this very serious problem. There is no emergency medicine in case of any kind of an accident available anywhere in Nye County.

I was recently on television with a county commissioner, Cameron McRae, also our assistant fire chief. And I asked him the question how many trained people in Nye County can handle emergency preparedness? These are the EMT, the firemen and so on. He said 12. I said "How many are on duty at any given time?" And mind you, this is Pahrump. He said "Six if we're lucky." This is very scary. And if--I said "You had an accident, what would you do?" And he said

"Leave town."

You know, I'm always making jokes, but this situation requires immediate action. I have e-mailed to the governor and to the legislature asking for a legislative audit, which is the realignment of counties so that rural counties like ours can have virtual schools, virtual medicine and virtual libraries. Now will everybody raise their right hand if they understand what I just described? A few hands went up. Thank you very much.

And this is what I'm running into all over the place, and I brought you a report on virtual medicine. Unfortunately I got it yesterday and couldn't get it copied, so I will mail it to you.

Would you believe that New Zealand, Norway, and the State of Iowa have virtual medicine? The State of Wisconsin has virtual schools, so does a lot of Minnesota, New York, South Dakota, and so on. We have none of this.

Our community colleges are starting to be virtual schools. Our libraries all but in Nye County are starting to be virtual libraries, and the State of Nevada is at least 50 years behind the times, but they're going to have to catch up.

Eureka County with 300 people got frame relays and now the 30 families that live there pay 30 bucks a month and they have virtual schools, virtual medicine and virtual libraries. This is the only place in Nevada that has that.

In all the years that I've been involved with you all and NTS and so on, I have never had any meeting with Ken Powers or DOE or George Davis or Dan Willems of TRW. Yet I've read all their brilliant reports, especially the TRW report on Yucca Mountain. And of course they have met with Tonopah, but there is no communication between Tonopah and Pahrump. Pahrump shortly within the next five years will have 60,000 people. Our potential, Tom Buqo said, is maybe 110,000.

We are in the shadow of the Test Site and Yucca Mountain, and in my opinion they are one, because you cannot study the effect of the colloidal movement of water from the Test Site to Yucca Mountain or the tritium or the what have you if you don't work with the Test Site. So that we've got a lot of science that comes off of the Test Site. We've got a lot of things.

But again we get into any emergency, radionuclide spills, whatever that may be coming here, and there is no facility to handle it. Nellis Air Force Base used to have 2,000 people equipped and they could go anywhere in the world. All of their equipment is in mothballs and maybe they have 1,000 trained people. The Test Site has no medical facility, Tonopah test range has nothing, and then southern or northern Nellis Air Force Base has nothing. Therefore everything is dependent on Nye County.

And so I hope everybody has met in the course of their travels the Lisa Crawfords or the other Sallies of this world. And she proved to DOE, living in Fernald (phonetic), that they had been very naughty, and as a result they got $42 million. This year the State of Idaho is going to have to pay $38 million if they're not out of there by 2038, and the people of Idaho Falls were involved in this process and they got money.

And so why am I asking the Board? I'm asking the Board because you are the only people that I know that can get us virtual medicine, that have the brains and the experience and so on; and we really, really need it, not only for emergency preparedness of any accidents, but for the local people that you're trying to get involved in this process.

Just one last sentence--okay--I want you--and you know three years I yelled at 21 acronyms--I have my concept which is you put together all the DOEs that are involved on the Test Site and at Yucca Mountain, the NRC, the EPA, the FBI, FEMA, USGS, NDOT, the State of Nevada, OSHA, OCRWM--and I have a whole list more, but in time I can't say it.

Now I'm going to ask that we get together on this because it is a major project, and one I know you people for all these six years and you are very concerned. But this has never been talked about, it's never even been suggested. And I'm going to ask--and I think it should come from the M&Os, for $50 million for this project.

Thank you.

COHON: Thank you, Ms. Devlin. I know this is not your point, but I think it should be noted for the record that indeed worker safety was a major criterion on DOE's--or M&O's analysis of design alternatives. You've raised another issue, and DOE has heard you, I'm sure.

Judy Treichel from the Nevada Nuclear Waste Task Force.

TREICHEL: Thank you. I just have to say something very quickly while Lake is still here, about this outrageous public comment period for the site recommendation. This project has been going on for 15 years.

In the last presentation that we saw about the LADS and the EDAs and so forth, that was an eight-month long project that happened within a million dollar a day program, that's loaded up with paid people. And you're going to give the results of all this, which come down to the site recommendation decision, which as everybody has said, is going--it's very important that it include flexibility.

That was the problem that we've had with the EIS. We wound up scoping one project and we're going to get a draft EIS very likely that's a whole different project. And to maintain this flexibility means that you could have an entirely different repository from the one that people were allowed to comment on; because all we get during a 60-day holiday period is time to make a final judgment. We don't get another shot at it to accommodate all of the flexibility that was left in there.

And this isn't a joke. It's know world wide. I recently came back from Bulgaria and Sweden and got to see an awful lot of several different waste programs, and this is the only country in the world that's speeding toward something like this. And there was a man in Bulgaria that said "how could the greatest democracy on earth be operating this way?" And I said "Well I don't know; I think there's a serious break between democracy and nuclear waste policy, but that's all we can attribute it to."

And this is a classic point, and very often there are complaints that real people don't get involved in this. Well I'm not sure how many real people would use a holiday period to dig through the sorts of things that we're going to have to do. And another example will be this summer when we know that we'll have the draft EIS. We will very likely have the EPA standard, and I've heard from several sources that we may be looking at the draft guidelines.

Well that's a hell of a way for normal, not being paid, to spend their summer to try and hit those sorts of things, where the big aim here is to maintain flexibility; but asking us to do a pass-fail. And we don't get a chance to fail the project. We don't get a chance to opt out, as all of the referendum give people a chance to do around the world.

So it's either a miserable sort of horrible game that goes on, or just a very unfair process that nobody has really put any thought into. The DOE never was able to come up with a public participation plan, and I think this smacks of the lack of anything like that, that ever happened in the beginning.

Thank you.

COHON: Thank you. Martin Mifflin from Mifflin and Associates, Inc.

MIFFLIN: I'm Martin Mifflin, and I come from a background where I started oversight work on the Yucca Mountain site back in 1981 for NRC, and in that process reviewed quite a bit of the earlier literature from the Test Site work, so forth. And I participated in the oversight activity up until about 1995, '96.

These comments are directed to the Board. All of you are relatively new, two or three years. And one of the reasons I came today, I wanted to make a comment after reading the last report to Congress and the Secretary.

I found it very comprehensive with respect to what

I would call the trees of the program, many, many issues, broad scoped. But I found it lacking in dealing with the forest of the project. And what I mean is, is that there's a lot of trees in this forest, they're very complex, and probably there's an unlimited amount of effort and time that could be dedicated to many, many of the uncertainties and the issues.

But there is one issue area that deals with the forest, and I think it's very important from the historical perspective, and where the actual site characterization databases, processes, et cetera exist at the present time. And I would like to make just a very, very specific comment as an example.

From the earliest days, about 1983 or '84, an above boiling design was proposed. And it could have been '85 that it came out in a document, but it was quite early on. And I think the Board would agree, based on comments and the focus, that insight to heater testing is very appropriate for such a design in such terrain.

And yet if you look very carefully at the decision point in time that will be made versus the databases that will be available and the amount of time to analyze it in terms of in situ heating at various scales, we see a very, very unfortunate situation and--for such a critical aspect of site characterization.

This is not the only example, and there's a lot of other areas that are similar. Almost all of these types of problems were recognized, the various issue areas, that have not be dealt with successfully or in a timely manner associated with the site were identified in a period probably between 1982, when the vadose zone positioning was proposed, until about 1986 or '87.

And if you review carefully project documents and oversight documents in that period you'll see that practically everything that you are dealing with today, with a high level of uncertainty as still being dealt with was identified in various and sundry projects were proposed to the padressees (phonetic), many of which never were executed.

The point I'm trying to make is that when I read the 1998 report to Congress and the Secretary, I tried to imagine myself as a congressman or the Secretary of Energy. And I got a good dose of current problems and issues and the relative progress, or lack therefore.

But what I didn't get a very idea of was where was the project with respect to viable decision making process, and whether the site was appropriate or not. And my feeling is that the Board, if they were asked to make that decision as a Board--which they will be, there'll be (inaudible) will be asked at least in some manner or another in a few years--I don't think based on what I've read in the report the Board would feel comfortable with some areas of decision making required for the overall decision.

And I think unfortunately that the Board has missed reporting on one key area, and that's program management and the object of program management. And my opinion, the evidence is relatively clear that some program management objectives have not been for site characterization, but have been to very, very--and very kind of circumspect manner to limit site information to carry the site along.

And one area has been or could be interpreted, when you consider how key the information is, such as in situ heater tests. They were started back in the mid-'80s and stopped. And now we have some that will give information after the key decision (inaudible). And I think that those types of things are very important for the Board to report on, because the management of the program determines how much uncertainty is dealt with during the decision making process.

Thank you.

COHON: Thank you, Mr. Mifflin. George Danko, University of Nevada, Reno.

DANKO: Thank you very much. I would like to first start with that much credit goes to DOE M&O for their guts and wits to introduce ventilation, and advancing into this stage; and I would like to praise the Board to keep this issue on the agenda. And today we heard the new concept which is a newborn concept, although it's an old concept at the same time, but we can see that it's in its infancy with some minor problems which needs to be improved.

All the solutions which we saw today, five or 10 of these using this new concept, were selected and these seem to provide more flexibility in operation and (inaudible) this higher flexibility method assessment and control of performance. That is what we saw.

But I do have a question whether or not ventilation, this preclosure ventilation provides better performance assessment results when compared to the old design without ventilation. So that's not quite clear. And is that providing better long term containment or not? How does this 100 or 50 years or even few hundred year long ventilation could affect the performance of the repository in the 1000-year time frame? That's not quite clear.

COHON: Should we ask to see if someone would like to respond to that?

DANKO: I think--I think I would like to handle this question, similarly (inaudible) that maybe we have the answer during the afternoon meeting, so it can wait until the end of the day to pose these questions.

But I would like to share some other questions here. Ventilation alternatives were selected in a record period of time, in a few months, which has never, never happened before. This was maybe too quick. And I think those alternatives which may have improved mountain oriented containment have been dropped out in a hustle (phonetic), and I'm not quite convinced that there was enough result to support that quick decision.

So I do feel that that the presentation showing the openness and the flexibility of selecting the license design will really be able to entertain many of the things which were in parts and bits in the other ventilation concepts, and they will no longer be on the table.

So that is my concern, and I would like to provide some suggestions--which are not questions. It may be the design alternatives should include a representative postclosure concept, maybe a closed loop ventilation which was within the first selection of eight but dropped out when it was reduced to five. So there is some arbitrary number of selections here which I don't feel is technically and engineeringly supported.

And maybe the last design could be open and raise the concept until it's really selected for license application, and will not be exclusive to some of the other ones which were not researched quite enough.

Thank you very much.

COHON: Thank you. Would someone be thinking about a response to this point about the effect of ventilation on performance and provide it at the end of the day? Thank you.

Are there any other comments that anybody would like to make or questions they would like to ask?

Using Dan Bullen's chairman's prerogative, I will note that we're ending this morning's session five minutes earlier than called for, which means we'll start five minutes earlier than the schedule says. We'll reconvene at 1:35, by my watch.

(Whereupon a lunch break was taken.)

A F T E R N O O N   S E S S I O N

BULLEN: We have a couple of quick announcements. I'd like to turn the microphone over to Jerry Cohon for one of the more important ones, I think.

COHON: Good afternoon. Could I have your attention, please? I have a very important announcement that concerns food. Earlier in my opening remarks, I basically invited everybody to our cookout tonight and I think I exaggerated a bit. Rather than creating a list of those who are invited and those who are dis-invited, why don't we just say I did not mean, how shall I put this, Federal personnel or their contractors except, of course, NWTRB; that's us. The whole idea here, of course, is for the local folks and the Board to get together. So, with apologies to our friends and others in DOE and the M&O, and though this will undoubtedly be the best dinner in Beatty tonight, we'd ask you to make other arrangements for dinner. So, sorry to do that, but you can understand why. So, the dinner tonight is for the local folks including State folks. With that, I turn it back to Dan Bullen.

BULLEN: I would like to take this opportunity to say we're going to spend about 20 minutes asking questions of Kevin Coppersmith from his presentation from this morning, specifically from the Board. At that time, I'm going to cut it off because I'd like to get the Jim Blink/Ernie Hardin presentations in before 3:00 and then we'll ask some more questions of all the people in this session. But, I've been approached by a number of people that I'm going to defer to Dr. Christensen. Norm had the first question and I will make a list of other Board members who have questions.

CHRISTENSEN: Kevin, I want to make maybe three points based on your presentation and Dick Snell's and then ask a question.

The first point is that I think while I understand the distinction that both you and Dick made with regard to differentiating conceptual models or conceptualization process versus an optimization, I might argue that there's no threshold between those two processes. They're really up gradient and the process is one that will lead to increasing specificity as to what exactly this thing will look like.

The second one is the flexibility and the notion of evolution that Lake talked about. It's what I think is important. It's important to recognize that it is a two-way sword. It's an opportunity for change as we get new information, but it also represents the potential of a moving target and that's an issue of process as we get into this.

The third point is simply then that the process for evolving, I think, becomes critical which is something that you talked about.

I guess, my question then is to what extent do you feel, looking now to the future, whatever design alternative is selected--let's assume maybe EDA II--do you feel that the LADS process to date represents a model for the process for the future? I guess, my assertion is that given the notion of evolution, a clearly laid out process for decision making becomes, I think, increasingly critical.

COPPERSMITH: Well, it maybe useful, Dick, for you to expand on some of the details, but let me give my feeling overall, I think, related to your three comments. The issue of it being a continuous process is true. You don't end conceptual design and say, okay, now there's a step function and we'll go to a different level of specificity. It's a process of evolution that will continue on.

There are aspects of the design as design concepts right now that may not change too much, that might get more specific, but may not change much. There are other aspects that might change quite a bit. That does lead potentially to this flexibility to be able to change and to optimize the design. It does lead potentially to this idea of a moving target of last month you said the design was this, this month it's that. But, that is actually part of a design evolution process.

As you get into a certain point, the basic design concept stays pretty much the same; the details will change. I think we're at a conceptual design process now. How far we'll get for SR is not clear, but it's clearly not going to be down to a level of specificity that's really needed ultimately for licensing.

But, the issue of what happens now, I think, will be more of one of optimizing or refinement than a wholesale consideration of alternative concepts. Again, this is once a selection has been made by DOE. That process of optimizing or doing detailed design refinements is one that considers the really true work ability, the issues of engineering, what really will work, what has precedent, how do these things actually work out.

That process, I think, Dick, our engineer, should speak to rather than a process person. Dick Snell?

SNELL: First of all, I agree with you on your first point. There's no hard line between conceptualization and then optimization. It's a transition kind of thing. I also agree with you that flexibility is a two-edged sword. Retaining flexibility is fine up to a point, but there comes a time when it can work against you.

Right now, we are still in a flexible mode and I have to say, first of all, that design generally is a response to requirements. That's what it's all about. So, flexibility is fine if you're responding to a set of requirements. If we have carried out this process to this point in time perfectly which is an unreal expectation, but if it's been done perfectly, then the fundamental concept that we've identified would be the right one and any design changes that occur from here on having settled on a basic concept--this is after various reviewers such as yourselves have weighed in and DOE has actually adopted one--having settled on that, then you don't stray very much from that core concept. It is a matter of embellishment or development of detail against that concept.

So, right now where we are with flexibility is, I think, in this process we have identified some of the key elements in the design, the things that are drivers. Jerry Cohon asked a question earlier about the sensitivities and what are some of the important factors that are involved, and I think we can identify generally what those are. If we can get to the point where those are identified and we've got some general agreement on the fundamental concept to take forward, then the flexibility lessens and it becomes more a matter of development of additional detail.

We're right now at a point where pending those decisions on core concept and how do we move forward, we are beginning to initiate some development of design going towards the SR, but until we get some concurrence on where we're going and then sort of back it down until people are generally comfortable with the concept, we have to expect that we might have to modify what we're doing a little bit. We're trying to make some headway now--that is right now--but at this point we still have the ability to redirect, and as time goes on, the ability to redirect without impact on budget, schedule, and so forth, obviously lessens.

That's kind of a--I hope it's not a murky answer. I realize I'm waffling a little bit, but I think that's the way things are going to have to work.

CHRISTENSEN: No, that's part of what I was asking. I guess, the other part which may be in a sense implicit in what you're saying is the actual process itself, the institutional process that leads to the decision. I think, on the one hand, I heard somebody comment there's an incredible progress in a short time on a difficult issue and some changes that were made over a brief period. The use of the core team, the kind of process that you described, Kevin, the kind of process now as we move this forward. I think, my point is one of being very explicit about the mechanics of the process, as well as the philosophy and science that--

SNELL: Yeah, I heard that in the question. I did not respond. But, I understand what you're saying. I do not think that this is the model for how we move forward. I think it's been a very effective model for the thing that we had to do. If we have come to a point or get to a point near-term where the core concept is reasonably well-established, I think the management of the design development becomes, what I would call, a little more conventional, if you will. If you've got a core concept identified, a set of requirements that are clearly identified, you can begin to use a more rigorous pure design process. This evaluation process has been like a lot of conceptual studies. You know, we've brought in more people. It's fairly loose, a wide set of opinions have been brought to bear, and as we go forward, I would think that probably we'd be a little more focused, would not rely as much on the kind of input that we had up until now. I don't mean that we want to close the doors on ideas, but a more conventional design approach will work, I think, once we get the core concept identified.

COPPERSMITH: One thing I should mention, in Chapter 7 of the LADS report, there's a discussion of those first recommendations for design refinement that would be the first ones to pursue following this activity. Jim will be summarizing those in his talk and get some feel for what the elements are and moving from the--or mediate too long.

WONG: Kevin, looking at your Overhead 12 and 16, this is sort of a clarifying question. Why is it that the category of license probability and safety mixed together? What's the definition of license probability, and therefore, what's the definition of safety? In looking even at this slide, if I think I understand it, say, you take the--

COPPERSMITH: Take a look at 10--or 12. This defines what these words mean.

WONG: Okay. But, why would you mix license probability and safety? I guess, my real question is which one of the designs is the safest design?

COPPERSMITH: Well, this was shorthand. In other words, safety is shorthand because, in fact, we're talking about things like dose. So, safety comes into play. And, licensing probability which was originally tagged licenseability issues of going to fulfilling requirements for a license and so on, we found out that "licenseability" wasn't a word. So, the issue is these are the types of issues, licensing probability/safety is a term that is used to signify all of these sub-elements. So, we could use any other term, but they basically fall into that category. Some of them are quantitative estimates of dose. They're, you know, performance calculations or comparison to a standard like the margin; it's just a comparison to a potential standard. Others are more judgmental; the issues related to uncertainties, engineering acceptance, how acceptable is this, what precedent does it have, can you demonstrate post-closure performance, and so on. They are more judgmental engineering judgement based on experience and looking at the problem. So, it's a category that describes not only some of the more quantitative aspects of calculated performance, but the uncertainties in that and the implications that there might be to demonstrating--you know, sufficient demonstration to get a license.

Again, it would be easy on a lot of the issue to say, well, let's go with what's quantitative, but we can calculate those list issues' dose, but in fact, there's other things that are important in developing a conceptual design. Some of these others like engineering acceptance, it was thought that would be very important in a licensing arena to be using aspects and elements of the design that have precedence. They've been seen before. They've been used before. They've been demonstrated before. Likewise, some of these others, the uncertainties groups like this and others that have said that, in fact, not only is it important that you avoid uncertainties, but also this may make licensing easier or may help the licensing process. So, other groups have gone that next step in saying, well, it isn't important just to avoid uncertainties, but it might have an impact on the licenseability. So, we've put it into those categories on that basis.

SNELL: May I add something? Briefly, there are a couple of implicit assumptions, I think, in the way we've established the category. One is that from a licensing standpoint, demonstrating safety is a critical element. I mean, presumably, before somebody grants a license, you have to be able to make your case with reasonable assurance. So, it has a safety orientation, public health and safety both preclosure and postclosure in this case, but the other assumption that goes to it is that not only must you have a safe case established, but you have to demonstrate it. Some of those categories there talk about engineering acceptance or using conventional practices, conventional techniques, well-established approaches to what you're doing. Do you have some tools that you can use to make the case clearly and that's the point that you all have commented on on a number of occasions. You know, can you make a clear case? Is it not something that's murky, but something that's straightforward and demonstrable.

So, I think, the titles may be a little misleading, but I think it's the ability to make a reasonable case for public health and safety and the ability to demonstrate clearly or state clearly that case that you want to make.

WONG: Well, I mean, I guess between, let's just say, EDA I and II, you must feel that the licensing probability and safety, the difference between whatever those values are, are sufficiently close because, as I would look at this, it would seem like you run the risk of, let's say, picking EDA II, of investing some money into it, and having it fail or versus investing a little more money and knowing that even by your own judgment that another design has a higher probability of success.

BULLEN: Chairman's prerogative, Jerry Cohon and then Paul and then, Leon, did you have something you wanted to say? And, Debra, too, I know. So, Jerry is next.

COHON: Well, I jumped in because my questions follow on directly the quest--the one question I'm going to ask follows on directly where Jeff was. I have no doubt that the LADS process helped the very smart and creative people in DOE and the contractor to develop interesting and valuable conceptual designs and, indeed, we see the results of that which would tend to confirm that. I am critical of the process though especially from the perspective of a member of a Board that has to comment now on what was recommended. The part that I'm most critical of goes exactly to the first bullet on Slide 13 which says there's no explicit value model allowing for flexibility in DOE's selection process. Indeed, but the flexibility so gained comes at the price of the difficulty of tracing the decision and understanding the basis for it.

We recognize, I recognize and I know the whole Board recognizes, that these decisions are subjective and that subjectivity cannot be avoided because you've got multiple conflicting criteria. Therefore, you must inject values, whether you do it explicitly or not, to arrive at a decision.

You said something very telling that captures, crystallizes, better than anything I could come up with as to the problem this presents for me. In talking about the table--that's Slide 12--you made a point and this is going to be a paraphrase; it's not a quote, though we should get the quote. If you are a person for whom licensing, which was shorthand for all this criteria in the first column is everything, you would choose 1, Alternative 1. And, that's just the point. Obviously, licensing is not everything for DOE. Otherwise, they would have chosen 1, but they chose--I'm sorry, the contractor. They chose 2 instead. Our problem is we don't know how much more important flexibility, construction, and costs than the others were that would lead the contractor to recommend Alternative 2 instead of Alternative 1. And, we don't know because there was a specific decision not to pursue an explicit value model.

The range is very large as to what the possibilities are. I'm not sure what to do about this. I don't know how we can reasonably comment on the recommendation that was made without understanding and knowing in some quantitative fashion what the values were that led to that decision. Obviously, I didn't pose a question; that was a rant.

COPPERSMITH: I'll assume it was a question, as well as a rant. I think part of the process, I originally had a slide that said one of the goals--I think, Steve Hora or someone on the decision team said our real goal is to bring order to a conceptual design process. This is just like a judge hammering and trying to get order or Dan Bullen trying to get order after lunch. There's a need for that process. This is an open forum and people want to understand how you arrived at the decision that you had made. Normally, conceptual design processes are done in a more closed door type of way. But, the issue here then is if we're going to bring order, then let's have some of the basic elements of the decision process there. Let's make sure we identify our objectives up front. Those objectives can span a wide range of things from really calculations to things that are judgments on what we think are important. Let's have involvement of DOE in that process, as well as the M&O, and hence, the integrated group.

Secondly, let's go through a process that is explicit on how they would evaluate against those criteria. So, we have the LADS report, we have the supporting reports that talk about the individual designs, how they work, how they would be configured, what the alternatives are, and how do they evaluate against all of the sub-criteria. That's information, if you will, for anyone reviewing the process.

Then, the final step, as you know, is one of value modeling. Now, going from this point where this is a comparative evaluation of EDAs, we could have stopped at the point of saying here are the criteria, here are the evaluations of each EDA against those criteria, but we went to this next point of actually making a comparative evaluation at DOE's request that allows them to see how they were relative to each of the criteria individually. So, we've cut down the last step to one of saying, okay, given that, what type of weight would be put or what value structure would be imposed on a multiple criteria. Right now, our view of this is that we would go simply with the model and we look for consistency. But, again, that's where I said it's possible to have a different value in that last step.

COHON: I just needed to pursue this further because this is exactly the central point for the Board. As many in this room know, an issue of great interest to the Board has been a below boiling repository everywhere or everywhere in the rock. And, we're so interested in that because of it's apparent relationship to uncertainty in our ability to predict repository performance in the future. That's one of many sub-criteria under the overall criteria of license probability and safety.

COPPERSMITH: Right.

COHON: There's no way for us to know whether the recommendation represents a reasonable tradeoff between this one key element, among many, versus cost or flexibility, let's say. Let me point out, it's completely reasonable for DOE or the contractor to say, well, wait a minute. We've got to balance all of these competing criteria, and therefore, Alternative 2 is preferred and that's because the other criteria are collectively or individually more important than this one issue that the Board keeps harping on. That might bee reasonable, but we can only judge whether it is reasonable based by knowing the relative values.

Finally, this is such a key point because even though this is a conceptual design and it's going to evolve to a specific design, what's likely to happen is that something that's a key part of Alternative 1 at this stage is going to be left behind and not considered from this point on. Or, if one attempts to consider it, it may be very difficult to achieve it with #2.

COPPERSMITH: It may be, but right now one of the advantages of EDA II is that it isn't necessarily that difficult to achieve, for example, the temperature goals. See, one of the advantages and it's the two-edged sword of having alternatives that change all the time on you is the fact that one of the real advantages of EDA II is its flexibility so it can change. So, the ability to go, for example, to a higher or a lower temperature design, let's say a goal, is the one that can be achieved. Right? So, they say, wait a minute, you told me EDA II doesn't reach those goals and now you say that it does. Well, it can, but to do it, there are certain things that have to happen; extended preclosure ventilation potentially. Those types of things can occur in the process of refining this design. That's one of the advantages. You can say, well, it's a disadvantage because it isn't fixed and I can reject it or accept it as it is, but in fact, EDA II, one of its real attributes is its flexibility to be able to go after a different temperature goal.

BULLEN: We're going to ask a couple more quick questions from the Board members. Paul Craig, next?

CRAIG: I just wanted to pursue the general theme that Jerry and Jeff were talking about, but get down a little bit into the trenches. When I try to think about how all the concepts of robustness or defense in depth might be related to these criteria that you have here, neither of them show up explicitly as far as I can tell, although there's places where you could probably infer them.

COPPERSMITH: No, it's actually part of--

CRAIG: Let me proceed and then we'll deal with the whole business.

COPPERSMITH: Okay.

CRAIG: With respect to the radiation dosage, if your analysis is anything like the analysis that was done in

TSPA/VA, everything is controlled by the canister. Now, you're got not only the canister, but you've got a mailbox on top. So, any alternative you come up with is about going to behave roughly the same with respect to radiation dose provided those engineered barriers don't fall apart. On the other hand, if they do fall apart, you may be in big trouble. The criteria you have seem to be of such a character that you can't really do any discrimination on those lines and I would say that's a potential problem with respect to robustness and defense in depth.

Secondly, going back to the point that I was making this morning, I look at your criteria for flexibility and I look at Designs 1 and 2 and they're pretty interesting because 1 is identified as the lowest flexibility of them all. And, yet, I look at it and I say it doesn't seem that way to me. It seems to me that you've got the spacing for tunnels on 1 about half the spacing of the tunnels on 2. So, if you want to go from a 1 design to a 2 design, any tunnels that you've already built in between two tunnels, the odd ones, you just don't fill them up in your EDA II design. And, since you won't build tunnels far ahead and tunnels are pretty cheap to build, you won't have that many anyway, that looks like complete flexibility; more flexibility, clearly more flexibility than Design 2.

And then, I say, well, why do you spill over outside the repository area? Why don't you just go three dimension? After all, it's a 3-dimensional mountain. If you were to put a layer underneath, 50 meters underneath the upper layer, you could put in another layer. And, that kind of thinking which, admittedly, requires going from two dimensions to three dimensions, that kind of consideration simply never got built into the process.

So, I'm just worried. It sort of looks like the process was prematurely constrained in a fashion which has the end result of failing to choose the safest design. That seems weird.

COPPERSMITH: Let me go back to these. Number one, DID, defense in depth, is explicitly one of the sub-criteria. On Slide 10, the bullet here, agree with defense in depth, the reason it's called degree of defense in depth is that it involves judgments, not just simply counting what would be considered principal barriers or multiple, diverse, redundant barriers, but also a consideration of things like common failure modes, more judgmental aspects at this point. Using the same types of materials, are they subject to the same type of problem that one might have--you know, the failure of one might affect the failure of the other and so on. And so, that was considered explicitly in the evaluation.

The issue of EDA I's flexibility, the issue of capacity is very important. We looked at the potential for additional capacity and that's where it is difficult for EDA I. It, in fact, can't go to high capacities without going significantly into areas that have now presently been characterized outside the so-called--

CRAIG: I just suggested a way of not doing that.

COPPERSMITH: Well, let me go to that because, in general, if you work in two dimensions, it doesn't work. During the course of the discussion in Phase 1, we did deal with stacked designs. Two layers, three layers were considered in that process. Part of the issue is then, you know, what we want ultimately in EDA I is as much thermal independence, as possible. We get into problems of the interactions of drifts that are stacked vertically. There's also we get into the issues again of characterized area and other things that will occur. But, that was a design feature, an alternative, that dealt with the potential for that type of alternative layout.

CRAIG: So, there is a low heat load design some place or other that looks at three dimensions?

COPPERSMITH: Yes. People were encouraged to think outside the box. I think we had one that, in fact, dealt with spreading them out still further to different units and different locations. But, there again is documentation of that.

The issue of changing the number of drifts to get from EDA I to the EDA II is not that simple. The waste package size changes. A key part of thermal management has to do with the heat output of the waste package, and to get EDA I to work, you need to bring down that heat output and that's why it goes to a smaller waste package design.

CRAIG: The point had to do with flexibility. If you wanted to go to a higher heat load, you would simply not--you'd change your waste package design, spacing, and so forth; you just not use one tunnel.

COPPERSMITH: Right. But, again, those are literally considered relatively major design changes compared to, say, extending ventilation.

Ernie?

HARDIN: Kevin, if I could add just one thought. On the multi-level repository designs that we did consider, we actually had people construct numerical models with multiple levels and the result was that we do have square root alpha T characteristic length for the heat transfer problem and that we're unable to separate the drifts by more than, let's say, 50 or 70 meters, and that that lies within the characteristic length for heat transfer over the time scales that we're talking about. So, even though on a particular level, we might have had, let's say, 25 MTU/acre, we didn't achieve what you'd think of as low thermal goals overall over time.

BULLEN: Okay. Well, we'll let Ernie maybe address that a little bit later. I'm going to try and rush this along because I still want to get Ernie and Jim Blink to get their presentations in in a timely matter.

Debra Knopman and Richard Parizek and then I'm going to cut it off. Leon, did you have something that can wait until 3:00? Okay.

Debra and then Richard and then we're going to move on.

KNOPMAN: I'll make this real brief. I want to take the questioning that Jared Cohon was doing one step higher in the sense that I continue to--when I first heard about the LADS process or was briefed in April, I had a big concern about the mix of policy and technical judgment. Now, I have it even more because it's not a question of engineering judgment versus engineering quantitative analysis.

There's another level of policy judgments that are sprinkled throughout this whole analysis. That's not a question of good or bad; that's just this is the nature of the problem that we have. I think it certainly makes our job as a Board much more difficult. I think it makes it very difficult for the public to understand. This is not transparent in that sense. The judgments about the closure period, the judgments about ventilation, the judgments about whether we should to into an area that's currently uncharacterized, the judgments about all sorts of operational issues of surface storage and things like that are all major policy judgments that M&O contractors are simply not in a position to make adjustments about. You can ask them. We have opinions, too. They may have opinions, but these are fairly large calls, it seems. And, to bury those kinds of judgments inside a technical process, I think it creates a lot of problems. It creates a problem for yourself and further down the pipe. I think it would be most helpful if there were some statement that the company could report that very clearly identified, explicitly identified, each of those issues because they all became imbedded in the judgments about preferring EDA to some of the other alternatives.

I'd just quickly ask you whether that consideration was given as being explicit about the policy judgments versus technical judgments. It's not just engineering judgment-in-play. These are public policy issues-in-play.

COPPERSMITH: I think in most cases the issues that you cite--and there are others--served as more boundary conditions to the study than anything else. For example, the closure period, we considered closure as early as 10 years after the completion of emplacement, which if emplacement is 24 years and we're dealing with something that's 35 years, to as long as 300 years. And, I guess, the question is why not longer, why not some other value? These are values that had been discussed as being let's look at how it will do. In spans of range, we've had--these numbers are in various documents. Let's use those as assumptions. So, there are a number of others that deal with the same type of thing. Is there any harm in going outside the characterized area? We'll know there will be additional studies, additional time, additional money, addition--but, those served then as a touchstone, as a boundary condition to this. It doesn't mean that, in fact, they can't be changed or violated, but we tried to make it clear what they are.

I guess what you're saying is to then put them as--to flag them and say, okay, this one is programmatic or policy, this one is technical, and I think, in general, the things that we've called very loosely knobs in the design. We can change the flow rate of ventilation, the duration of that ventilation, the drift layout, the size of the waste package, and so on; those are all knobs. But, some of these other issues, we've treated as relatively given and then tested sensitivity like the closure period. We said, well, let's use the 50 years from start of emplacement and we'll assume that's the case across EDA so we can compare them and then evaluate for sensitivity how well they do in longer or shorter closure. But, again, some of those are clearly policy issues. Lake talked about it in his discussion; the issue of preclosure ventilation. Can we go for a long period of time? In this type of design activity, we get up against policy issues all the time. What we've tried to do is to deal with them as essentially boundary conditions and call them out. This is a good example.

The other issue of changing your design length, going from a hot temperature to a low temperature design, why would that ever happen? Well, the engineers have told us that has happened before. It might be we have new findings, the tests show things that we didn't expect, or there are ways that we need to adapt. They said, hey, we're much better off going to a lower temperature design. Can we do it with this design length? I mean, we tried really to brainstorm the types of things that were considered to be important and we've tried to make them explicit in the criteria like the five year and all of those. Many of them are policy calls. I think, DOE acknowledges that they are policy calls and will consider those in their selection.

KNOPMAN: And so, you've given them the adequate information to decide whether that policy called--what the impact would be if you changed that constraint. So, they would--

COPPERSMITH: I hope so.

KNOPMAN: And, that's in the public record?

COPPERSMITH: Yes, and Jim will talk about, for example, what happens--you know, the question came up what if we have extended ventilation for, someone said, 75 years rather than

50? We've done some of those calculations and we've looked at them to show the effect. You know, the question is if you change the EDA temperature goals to EDA I, what would it take to do it? How much more ventilation for how long? We've tried to, you know, get those types of questions to see if we can answer those. But, those are leading to, what I would consider to be, a selection call on DOE's part.

BULLEN: Perfect segue, Kevin, and my esteemed colleague, Dr. Parizek, said he would defer his question until the end of the Jim Blink and Ernie Hardin talks. So, now, we're going to move right on. Thank you again, Kevin.

Now, I'm unfortunately late, but I'm going to put the pressure on my next three speakers to try and be done by an hour from now, a quarter after 3:00. Can we get those done? I realize that's tough. You might have to pick and choose.

Our next presentation is Consideration of Uncertainties in Engineered Barrier Systems for License Application and Design Selection by Jim Blink. Jim, it's all yours.

BLINK: What I'm going to talk about this time is the uncertainties in the engineered system, particularly the materials. One point I'd like to do to preface this is to realize we're not just trying to reduce uncertainties, but where we can by design choices, if we can avoid an uncertainty entirely, we'd like to do that; reduce it, if not mitigate it if we can't reduce it to something beyond a level that we can tolerate.

I'm going to walk through the four materials that we're using in the engineered system; carbon steel, stainless steel, Alloy 22, and titanium and tell you some of the uncertainties that we identified associated with those materials and how we tried to tailor these EDAs to best deal with those uncertainties. I will also talk a little bit about changes in the water chemistry at the engineered material surface. Then, the other two bullets just are tie-ins to other talks that will follow.

All right. First, the carbon steel. In the VA design, we used carbon steel as the outer waste package barrier. It gave us excellent structural strength. It gave us a rugged handling surface. Finally, it gave us a sacrificial material, a corrosion allowance material, that would delay the onset of corrosion of the material that was giving most of our performance, the underlying corrosion resistance material during the thermal pulse where uncertainties were the highest.

Now, going to the EDAs, four of the five EDAs did not use carbon steel and that was to avoid an uncertainty. We had identified a potential uncertainty called oxide wedging. As the carbon steel corrodes, the expansion of the corrosion product pushes on other materials that are confined by it and can buckle the inner shell or split an outer shell. So, we decided to try to avoid that mode entirely by just eliminating one of those two materials from the combination. General corrosion is more rapid, as well, for this material. Now, we still have the potential of using carbon steel with the EDAs in the ground support, the waste package support, or the invert. That's not a choice that's been made in all three, but it is an option or a candidate. We would have to design these components so that we don't set up a geometry that could lead to that same failure mode with the waste package or the drip shield and also to worry about hydrogen embrittlement, another mode that carbon steel corrosion can cause in the corrosion resistant material, and I'll get to that one later.

EDA IV was the EDA that did use carbon steel. In this case, it used a single layer, 30 centimeter thick carbon steel waste package sort of going in the other direction. And, we used backfill in that design to elevate the temperatures and to suppress the relative humidity so that we didn't have corrosion starting on this material early-on. That combination of thermal engineering plus the thick material gave us a lifetime in excess of 10,000 years for that waste package. However, after the 10,000 years, in the 15 to 20,000 year range, a substantial number of the packages would fail; whereas, the other waste package designs that we looked at would last much, much longer into the hundreds of thousands of years.

Another mode of failure of carbon steel is pitting and pitting is likely in alkaline environments, particularly those that are influenced by concrete. As Bob Dulin told you earlier, we've tried to minimize the amount of concrete in the area of the drift to avoid some of the questions about concrete's effect on corrosion, on waste form mobilization, and on radionuclide transport. We do model pitting of carbon steel in the performance assessment. One of the conservatisms we have in those models is we assume those pits would go all the way through even a thick material and it's probably more likely that a pit would stifle or cease to grow before penetrating the layer. So, we were conservative there.

Now, onto the stainless steel. Four of the EDAs used stainless steel as the structural material, but in a way that's opposite of the way that we use steel in the VA. In the VA, we put the structural material on the outside, let it be a sacrificial corrosion material. So, as it corroded away, the structural strength continuously degraded and we were in the position that at about the time that rockfall uncertainties get the worst, our structural strength was dropping. So, we had two uncertainties coming together and made it very difficult to predict that kind of performance. What we've done in these EDAs is we've put that structural material underneath the corrosion resistant material so that the compromising of the structural strength doesn't begin until the corrosion resistant material is breached which may be 100,000 years or more, perhaps. So, the structural lifetime of these four EDA packages is much longer, maybe over 100,000 years; whereas, the VA design, it was considerably less than 10,000 years.

General corrosion of stainless steel is very slow compared to the carbon steel, and if that's the dominant failure mode, the structural shell alone would provide us greater than a 1,000 years of corrosion lifetime. However, because of the uncertainties in localized corrosion of stainless steel, we didn't take any credit for that corrosion resistance in the performance assessment. Going to those localized failure modes, pitting is aggressive if we don't have buffering chemicals in the water that's contacting the stainless steel. In our situation where the temperatures will be back to ambient and the environment is fairly benign, with buffers we may not have a pitting issue with stainless steel.

Stress corrosion cracking is not an issue for our stainless steel until water can get at it and that's a long time into the future. But, uncertainty and variability in mechanical stresses that are caused by the assembly of the multiple layers of the waste package would require further investigation if we wanted to take credit for this material. Overall, the low temperature, the low thermal stress, and the buffered environment conditions at the time that the corrosion resistant material breaches, that's the time that the stainless steel becomes attacked, might lead us to significant performance, but we didn't take any credit for it because of the uncertainties.

Let's go on to Alloy 22 now. Again, four of the EDAs used Alloy 22 as the outer shell. We put it in the outer shell for that structural material protection purpose, but also to avoid another corrosion mode. Crevice corrosion was of great concern to us in the VA design. We had two materials that were not metallurgically bonded. So, when the outer material breached, by capillary forces we could get water into that space in between and the chemistry of that water could evolve in such a way that even a very robust material like Alloy 22 had some uncertainty in its lifetime. In this situation, we removed that geometry by putting the Alloy 22 on the outside. Of course, we will have to take some steps to make sure that we don't create an environment in another way by the way it sits on a support, for example.

We've also limited the temperatures in these four EDAs because crevice corrosion is a thoroughly sensitive process and we would like to limit the temperatures to avoid it if we can. We did that by using preclosure ventilation and for three of those EDAs also by using blending, so that the hottest waste package wasn't much hotter than the average package.

Finally, we limited seepage water contact because seepage water is more important for crevice corrosion than condensate would be because of the dissolved minerals in the seepage water. We limited that seepage water, particularly when the temperatures were high, by putting a drip shield in between the seepage and the waste package. Those are methods to address a little bit of Dr. Nelson's question.

We did seek to try to optimize the way the engineered barrier compliments the already good barriers we have in the mountain. The low seepage in the mountain is an advantage and we took steps to preserve the low seepage by thermal engineering and by putting another component between the engineered barrier, the waste package. So, we were trying to put them together and I'll give you some other examples in the second talk.

For EDAs I and II, the lower temperature designs, we set them up so that they would return to low temperatures well before the drip shield corrodes so that we wouldn't see high temperature seepage water. And, finally, for EDA II, we added backfill to that design to thermally limit the relative humidity because without the relative humidity the amount of water that can get at the package and the aqueous films would be decreased.

Onto general corrosion and pitting of Alloy 22, the general corrosion is extremely slow and we've been measuring it in tests and Joe Farmer will tell you about some of that tomorrow, I think. The bottom line is if that is the dominant mode, that two centimeter thick layer of Alloy 22 would last for over a hundred thousand years. We don't think that pits would initiate an Alloy 22 at temperatures below the boiling point of water at the repository elevation. If we arrange things so that water doesn't get to the waste package--well, in that sense, we would have pitting no matter what happened.

Crevice corrosion is more complicated than the pitting and I've laid out three situations for you here. If we had clean metal and no dripping water so that the only water that would be on the film would be water that condenses directly onto the waste package or onto the drip shield and drips down from the bottom side of it, in that case we probably would not initiate crevice corrosion at any temperatures below the boiling point of water and so it wouldn't be an issue.

The next situation we have is if somehow the aqueous film would have some minerals dissolved in it, some salts. In that case, if there isn't a large amount of salt, we maybe could initiate crevice corrosion at temperatures above 85 degrees C.

The third step, the one that's the more problematic one for doing the performance analysis is if the aqueous film becomes saturated in a salts and I've used 2000x J-13 water as the example here and in that situation, we think that crevice corrosion might initiate at temperatures above 85C and maybe down to 50 percent relative humidity. We will try to avoid that third situation by design. We'll use Alloy 22 as the outer shell to avoid the crevice corrosion geometry. We'll pay attention to the geometry of the supports with the waste package and detail design and we'll try to avoid this region.

We'll show you in a couple of later talks on this temperature versus humidity graph a trajectory of the direction that's followed by particular waste packages through this space, but I've tried to plot out on the space the regions where we would be concerned. The pink region up here is that middle situation I told you about where you have some aqueous films, but you don't have enough salts in it to cause you a lot of problems. The yellow region is the region where you have lots of seepage, water evaporating off a hot component, or a concentration of salts and then maybe dryout and then rewetting of the salts; so, a worst case situation.

The temperatures I've given you, 85 degrees C, is an extrapolation of some NRC data that was gathered fairly recently which indicates that's the lowest temperature at which crevice corrosion would be seen in 1M NaCl at either acidic or fairly neutral pHs. They ran both pHs. 125 degrees C is some data from Livermore at which they subjected waste package materials to heat and continuously boiled the water off until they saw--with the salts elevated to boiling point until they saw the point at which the last water disappeared. So, those are the windows that we'll show you later.

BULLEN: Jim, this is Dan Bullen. At the risk of offending my colleague to my right, Alberto Sagüés, and in expediency of time, Carl Di Bella has made some suggestions about the graphs that you should skip. What we'd like to see are actually 14 and 15 and 20 to the end. So, I hate to drop off stress corrosion cracking and hydrogen embrittlement, but go to 14 and 15 and then 20 to the end and we'll see how it goes. Is that okay?

BLINK: Go to 14, all right.

BULLEN: It's like a PhD exam. You have to think on your feet now.

BLINK: Hey, that's all right, Dan.

BULLEN: Okay.

BLINK: All right. As long as I get to skip the questions on those two modes, all right.

Okay. Phase transformation is an area that's of some concern for Alloy 22. Alloy 22 is so good because of the alloyed elements that are in it, but as you know, the alloys are metastable and over time with temperature they evolve. Alloy 22, when you hold it for extended periods at high temperatures, some phases grow in that concentrate alloying elements into those phases which leaves adjacent regions depleted. This can lead to two potential failure modes. One is embrittlement and cracking; the other one is if those adjacent regions are depleted in materials that form the protective oxides for some pH conditions, then in those pH conditions you could have corrosion through those regions much more rapidly than otherwise expected.

Alloy 22 has a host of alloying elements that cover the entire pH spectrum. So, it is an excellent material from this viewpoint. So, we have to look at the phase transformation. Fortunately, one of the vendors of Alloy 22 has been testing these materials for over five years at elevated temperatures and they were kind enough to provide some samples to the program. So, we've had the advantage of being able to use materials. The bottom line of this is somewhere in the range of 300 to 350 degrees C. We don't believe that there will be a problem at temperatures below that with the ingrowth of phases, these potentially detrimental phases into the base material. For weld material, we have to go a little further because some of these phases are actually nucleated during the welding process itself.

Long range ordering is a related phenomenon. It's also thermally-driven and it's a rearrangement within the grains of the crystalline structure and that could potentially increase susceptibility to stress corrosion cracking and we have really just begun to work on this one and to evaluate its potential modes for this material.

Now, to 20, I guess. For the surface chemistry, this is sort of a summary of the earlier slides, some of which we skipped. So, I'll walk through it quickly. The reactions at the corroding surfaces are very important. We can go on to characterize the water that's in the rock or the water chemistry that might evolve as evaporation goes on, but we also have to look at what happens right at the engineered material interface. Microbiological activity can lower the pH, and if your material is susceptible to low pH, that could be a problem. Fortunately, for us,the titanium and Alloy 22 are two alloys that are not very susceptible to acid pH. So, microbial corrosion, we know microbes are in Yucca Mountain as they're almost everywhere. We know that they will grow and form communities if we put them in proper conditions, but we don't think these materials are very susceptible to the result.

Crevice corrosion, I already talked about in the VA design. Crevice corrosion was an issue to us because there was a potential to form ferric chloride in the crevice and ferric chloride was one of the most corrosive media around. That's why the corrosion engineers use it as a bounding environment.

Aqueous corrosion of iron either in carbon steel or even in stainless steel that's in contact with titanium could generate hydrogen which can diffuse into the material causing it to embrittle and so we have to avoid that situation by not setting up a geometry where we've got raw iron, uncorroded iron, right up against these materials. And, we think we can do that.

Finally, the evaporative deposition of salts on the drip shield and on waste package surfaces can in one case be protective, but in another case can provide crevices which could be detrimental. We've tried to avoid that situation by using the backfill to protect the drip shield and the drip shield to protect the waste package.

In the EDAs, as I've said, we've tried to use our design flexibility to take advantage of this knowledge of potential failure modes so that we don't have to make an argument about a mode not being a problem because of magnitude. We want to make the argument that it's not a problem because we haven't put the materials together in a way that the mode could occur. The titanium in Alloy 22 are very resistant to acids. The drip shields minimize evaporative depositions. Backfill further helps that. We used those materials and those geometries and components in the EDAs. We've avoided carbon steel-to-Alloy 22 crevices in every case and we think in detail design that we have enough flexibility left that we can separate steel members from these corrosion resistant materials.

The bottom line of this is the EDAs consider known degradation modes of engineered materials. We use thermal, geometric, and material interface design choices to either preferably avoid, or if we can, to mitigate the modes. Our confidence in the EBS performance is enhanced by three things. One is the defense in depth. We've used multiple materials with different mechanistic behaviors. We're doing testing and modeling at scales ranging from the atomic scale up to continual to get mechanistic understanding. Since we're extrapolating so far in time from our database of materials performance, we really need mechanistic understanding. Finally, performance confirmation testing. In site characterization, as well as in performance confirmation, we've taken every opportunity we can to expose these engineered materials to the ambient or accelerated conditions and tests that are being run for other purposes.

BULLEN: Thank you, Jim.

For those of you that are following along, we dropped the section on the titanium drip shield information which really doesn't differentiate between any of them because it was background material that all of them have a drip shield and we can defer questions on that to some other time. In fact, I'm going to defer questions for Jim until after we've had the three presentations.

So, I'd like to ask Dr. Ernie Hardin to come up and talk about his presentation on Near-Field Environment and Coupled Processes, Effects of Uncertainty.

HARDIN: Thank you. I've got a number of notes here that I've made during this morning's presentation. So, I can provide a little more detail on topics of interest.

A quick outline of what I'm going to talk about here. I want to touch very briefly on the way that scientific uncertainty was handled in the selection and development process, review some uncertainties in a rather general way, and then go in some detail into how these uncertainties were addressed in development of the EDAs. This presentation is a high-level conceptual presentation and deals mainly with near-field and the engineered barrier system, but not including the waste package, its contents, and corrosion of the drip shield.

During the development and selection process uncertainty was addressed in the multi-pass process approach. When it came to EDA evaluation, the licensing probability/ safety criterion is that which embodied the considerations that I'm going to talk about today. I'm not going to dwell on this except to say that the overall process of dealing with uncertainty in this study that I'm going to talk about right now really pertains to Phase 2 and I'd like you to understand that, of course, there's a backdrop here of a Phase 1 evaluation, extensive and in most cases quantitative evaluation, of 26 design features and five design alternatives. So, we have a pyramid of documentation.

Okay. To quickly review some of the uncertainties that we're talking about here, I want to go through a couple processes and sort of give a very quick synopsis of where we are. In thermal-hydrology, we have improved predictive models. We've been doing this kind of modeling for over 10 years. We have run three field tests at Yucca Mountain plus we have done field tests at G-tunnel. So, these models are evolved. However, we do feel that there are uncertainties here, and especially since the models generally predict the average behavior of the system, that there are some uncertainties that get to how robustly they can support arguments to a licensing safety case. In particular, the parameterization and the quantification of fracture capillarity, the fracture-matrix interaction which is a matter of ongoing development, the hydrologic property sets that are used in the models for which there are parameters that we cannot measure directly and are inferred, and in general, the spatial heterogeneity of fracturing in the mountain.

Turning to thermal-mechanical processes, we do have event simulators here, as well. However, some of the parameters that we would put into those simulators, such as the constitutive relationships, are generally uncertain. For example, in the area of constitutive relationships, I think that there will be a first cycle loading effect that is seen by the rock mass. It's going to be stressed on heating, and on cooldown, it's going to exhibit some hysteretic behavior. We don't have any directly relevant data on that effect. In addition to boundary conditions it would use for such modeling and the longevity of ground support--we're talking postclosure, but in the near postclosure time frame--are other uncertainties.

Thermochemistry is an area where we also have advanced models, models such as EQ-36 and the supporting databases. Again, we have some limitations to the applications of such models, in particular, to chemically heterogenous problems. And, by this, I mean that we have multiple phases, spatially heterogeneous phases. We have heterogeneity at different scales, grain scale all the way up to heterogeneity controlled by fracture scale or fracture distribution. In addition, the thermodynamic tools that we have are generally limited to concentrations on the order of one molal. When we act slow to the problem, then we compound certain uncertainties and, in particular, the intrinsic rates or chemical reactions and the reactive surface area that is present in the rock are things that are difficult to measure. We have parameters, but again we're talking about a robust capability that we would make a pillar of a licensing safety case or in this case a design alternative evaluation. So, we tend to keep these uncertainties in mind and address them in the evaluation of the EDAs.

Moving to thermal-hydrologic-chemical coupled processes, here we're talking about changes in fracture hydrologic properties potentially clogging the fractures, although the fracture porosity may be high enough, on the order of a half a percent of more, that clogging may not be an issue. But, in addition, there are some uncertainties related to the extent of fracture-matrix interaction before and after the thermal pulse. That is that the waters that are flowing along fractures are going to imbibe into the matrix and then evaporate will change that hydrologic characteristic and thereby change the non-equilibrium aspects of the hydrologic flow system. And, finally, chemical fractionation which I'm using here to refer to the idea that saturated volumes, for example, could be expected to be more mobile in the thermal regime than fresher waters. That is they get closer to the heat source. We expected zonation, but we don't have any directly relevant data on this effect yet. So, that was also an uncertainty taken into consideration here. And, finally, the effects of some of these processes on radionuclide transport in the unsaturated zone and again we're talking about reactive surface area, changes in the composition of exposed surfaces, and fracture-matrix interaction.

So, in general, the treatment of uncertainty really addressed our capability to resolve uncertainties in a licensing time frame in such a way that these would become important aspects of our a licensing safety case.

Moving onto thermal-hydrologic-mechanical models, I mentioned the effect of unloading on cooldown. We have some estimates that we can expect maybe order of magnitude increases or decreases in bulk permeability, fracture permeability. Again, we had some observations from field tests, for example, from the single heater test, but there are attendant uncertainties. So, in general, the relative magnitude of the effects from THM coupled processes are bounded, but they are uncertain.

And, finally, this last category of coupled processes, THCM, refers to processes such as pressure solution or cementation. We know these processes exist. We've actually created some of these processes in the laboratory, but we're not quite ready to extrapolate to field scale long-term conditions. So, there's a bit of uncertainty with regard to the relative magnitude of those things, as well.

Okay. Shifting gears a little bit to talk about the CRM environment, we recognize uncertainties in the temperature, relative humidity, behavior of liquid water, and mechanical loading of the CRM barriers. In addition, within the in-drift environment, there are bound to be variations in pH and the availability of chemical species that affect corrosion reactions. Also, we recognize that the materials which contact the CRM barrier, such as the invert material that potentially supports the waste package, contacts the waste package pedestal, and the backfill material that could come in contact with the drip shield, all will have some bearing on the long-term performance of the CRMs.

Finally, in this review of uncertainties, the stability and predictability of in-drift physical and chemical conditions was considered fairly extensively in this process. Here, we're talking about the effects of rockfall on the drip shield and the waste package. We're talking about uncertainty in characterizing the properties of a debris-backfill that would occur if we didn't have an engineered backfill. We would expect that the particles would eventually fill up the portion of the drift around the waste package and drip shield. We addressed some of the uncertainties related to performance of water diversion barriers. In the Phase 1 of this study, we looked at the Richard's Barrier, as a capillary diversion barrier in lieu of the drip shield, and the longevity of that Richard's Barrier was a matter of some uncertainty. In addition, in this category, of course, we have chemical evolution of introduced materials, such as steel and notably concrete.

Okay. So, moving on, I'd like to talk about how these uncertainties addressed are addressed in development of the EDAs. First on the list is the design for lower temperature and faster cooldown. When you add a drip shield and make extensive use of CRMs in a range of design alternatives, thermal management emerges as one of the principal degrees of freedom in differentiating among alternative designs. For EDA I, the drift wall temperature is maintained below boiling, at least according to our calculations. The smaller waste package greatly assists in meeting this objective and no backfill. By doing that, we decrease both the rates and the cumulative effects of coupled processes, in particularly, THC coupled processes. For EDA II, we address the same objective. We keep the pillars mostly below boiling and we use an argument that's based on a fairly conservative model to come up with drift spacing in reference to this objective. And, we maintain the drift wall temperature at less than boiling, but after a few hundred years.

Okay. Moving on, these are some reports that come out of the LADS final report of which there is a copy over here for you. This is a calculation done for EDA I and I'll shortly show you one for EDA II. These are relative humidity versus temperature trajectories for collection of waste packages. This is done using a multi-scale thermal-hydrologic modeling approach, the same approach generally that was used for the VA. EDA I, of course, does not have backfill and this calculation was done assuming 50 year ventilation in which 50 percent of the heat would be removed during that period only. The trajectories that you see here represent a range of locations in the repository, i.e. from the edge to the center where the edge is generally cooler, and represent different types of waste packages, specifically different types of waste contained in the packages. So, we have the cooler defense high-level waste and then we have commercial spent nuclear fuel.

And, I have overdrawn Jim Blink's window of crevice corrosion susceptibility for Alloy 22 here; this boundary being limited by 125 degrees C temperature representing boiling point elevation effects, this boundary representing the absorption of water by salts. So, generally, we see for EDA I we avoid the window of crevice corrosion in this sense and in this sense we avoid most of it.

Moving onto the figure for EDA II, now the idea here is that these are thermal-hydrologic calculations that get to the average behavior of the system. So, the calculations are done with the long-term average climate. So, we feel that they are representative of conditions one might expect over most of the repository layout. However, if you have a region where you, say, had episodic influx into the drift, you might expect, if that influence lasted a long time, the relative humidity to go up which would take you higher, but the temperature would go down. If you had a transient situation, where you had a hot, dry drift in which you had a truly episodic influx event, you might expect for a brief period that the relative humidity would go up without substantially changing the temperature. So, there are conditions that we can come up with that represent variations on the thermal-hydrologic modeling that could take some of these trajectories into that box.

The same really could be said for EDA I. I would point out that these calculations for the previous slide which was #10 that the--can you put the previous one up? Yeah, these are made using a collection of models of the combined 3-dimensional and 2-dimensional models. We're not explicitly dealing with movement of moisture in the gas phase down the axis of the drift. Okay?

So, moving onto Slide 12, please? Another way that coupled processes were--or coupled processing certainly was addressed in the study was by actually designing for higher temperatures for a long time to prolong the return of moisture and the time until return of moisture. Of course, this was done in EDAs III, IV, and V simply by going to a higher thermal load. EDAs III and IV had thermal loading conditions similar to that in VA. EDA IV added backfill and EDA V uses even higher thermal loading to accomplish this. This is basically a tradeoff of timing against long-term predictability.

Another way that we addressed uncertainty in coupled processes is by limiting reliance on prolonged low humidity conditions in the backfill. Now, in EDA I, we use--it's essentially a low temperature design rather than a low humidity one. For EDA II, we get some lowering of humidity because of the thermal blanket effect of the backfill. But, there are uncertainties related to that. For EDA V, which is not backfilled, we get the same effect of extending the dry period, but we use high thermal loading to do that instead.

Another way we've addressed coupled process uncertainty is by designing to increase reliance on local heat and mass transfer processes; emphasis on local. EDAs I and II do this by limiting multi-drift effects. What we're really talking about here is the effects that involve mass transport and storage of condensate water. Clearly, the question of heat transfer by conduction-only is addressed on a kind of multi-drift basis that--including for EDA I and II, we use symmetry models, for example. But, the essence of this point is that with EDAs I and II, we have limited the possibility of condensate collecting and moving from one drift to the vicinity of another. For EDAs III and IV and V, one has to appeal to multi-drift models at larger scales in order to come up with similar or predictions of thermal-hydrologic performance that have similar reliability as the ones that we would do for EDA I and II otherwise.

Moving to Slide 15, another way that we've addressed uncertainty in coupled processes is by going to line loading. Now, there are some simulations out there. There are not a whole lot of 3D thermal-hydrologic simulations and there are very few 3D THC calculations. But, generally, what we've been able to learn from the preliminary work in that area is that cold waste packages proximal to hot ones tend to bear the brunt of mass transport and that you want to go to line loading and want to use blending to make that line load more uniform. We've made pretty little application of these concepts in developing the EDAs. And, that application is based primarily on predictive models.

Moving to Slide 16, there are some uncertainties associated with the duration and the effects from warm and moist conditions in the drift. We've addressed these in some of the EDAs by using a CRM, outer waste package barrier in lieu of, let's say, carbon steel, especially in the low thermal concepts. When you go to low thermal, you need something to protect the waste package during a period early in the thermal evolution of the system when you have moist, warm conditions. In addition, we've looked at design alternatives that would have rather more spent fuel in each package and that's what I mean by waste package energy density. When you do that, there's a tendency for the thermal output curve to flatten out at a later time and the question is what is the system temperature when that flattening occurs? If you put a lot of fuel into a package, then that temperature is at boiling for those several thousand years out there. So, by keeping the amount of waste in a package down, you get through that zone and then you flatten out at a lower temperature.

Okay. Postclosure passive ventilation was not used and this gets to the question of is it better to use models that emphasize local heat and mass transport processes. We looked at some postclosure passive ventilation designs, closed loop designs. They generally involve taking air and conducting it through openings that are not--where waste is not emplaced and thereby moving heated moisture from one part of the mountain to another. They involve collecting air, moving it through passageways that are subject to rockfall, subject to collapse, and they also involve balancing the process. That is to say that when we ventilate the repository preclosure, there will be adjustments made. There will be valves and doors that are used to control the ventilation air flow. We will not have the flexibility to make those adjustments during postclosure. Therefore, it's going to be more difficult for us to maintain that we have a uniformly effective postclosure ventilation approach. So, because of the uncertainties associated with that closed loop concept, it was not included in any of the EDAs.

Okay. One way that we addressed the uncertainty related to coupled process chemical effects is by thermal management. Generally, by limiting the rock temperature to below boiling, we get away from the effects of boiling which are sharper transitions in the chemical effects, and by going to a lower temperature design, we're able to remove more heat by conduction and relatively less by evaporation which then limits the amount of solute moving around in the system. So, we've limited the rate of a process and we've limited the sharpness of its effect.

Clearly, the drip shield protects the waste package and that turns out to be a pretty important aspect of the design. Subsequent to the LADS study, it's become apparent that one viable approach to the safety case may be to try to bound the effect of coupled processes on the drip shield while developing a more realistic model for the waste package itself.

Okay. Moving on, another we would address coupled process chemical effects is by designing to delay the onset of those effects. By using preclosure ventilation, clearly, we delay it somewhat. EDAs III, IV, and V, also by going to a long dry period, delay the onset of coupled processes.

For the in-drift physical environment, the uncertainties associated with properties of rockfall, the mechanical effects of rockfall are just placing backfill. Backfill is a clear choice to mitigate rockfall mechanical effects. It stabilizes the geometry of the EBS. Here, we're talking about toppling and rolling of the waste package, toppling of the drip shield due to ground motion, potential effects of faulting on the system. Backfill will stabilize those effects. In addition, backfill has more predictable heat and mass transport properties, for example, thermal conductivity, than would a natural debris-backfill. And, it also simplifies hydrologic responses. For example, thermally-driven reflux without backfill, you could have a dripping response. Whereas, with backfill, you will have a capillary response; the capillary response being more easily predicted.

In addition, you know, I have to mention that the water diversion barrier being the drip shield significantly decreases the potential for advective releases of radionuclides. Particularly, we find this useful for the case of the juvenile failed waste package. So, if you're having an intact drip shield over a waste package that has some sort of defect in it, maybe one in 1,000 or one in 10,000, it is protected for the life of the drip shield substantially from advective release of radionuclides. And, if we have independent failure distributions for the so-called juvenile failure of the drip shield and the waste package, then we have very low release rates in 10,000 years.

Moving on very briefly to the in-drift chemical environment, as you can tell a couple of times today already, in the development process we have limited the use of cementitious materials. All EDAs would use steel as a principal means of material for ground control, but they would not necessarily eliminate the use of grout. The use of backfill also, as pointed out by Jim Blink, would chemically isolate components of the EBS that are not supposed to touch each other, such as uncorroded carbon steel and titanium.

We gave some consideration in developing the EDAs to the use of buffer materials. Specifically, a couple of things that are possible are silica buffering which would take alkaline solutions down, but it's not very effective because it's solubility limited, and carbonate buffering which would tend to limit the occurrence of low pH conditions at the surface of the CRM barriers. These have not been explicitly incorporated into any of the EDAs presented to you, but that does not mean that they won't be in further detailed design. And, in particular, a couple of things that might be worth looking at are the use of a carbonate rock aggregate as the invert material and the use of some form of carbonate in the backfill.

So, to summarize, uncertainty of postclosure performance was definitely emphasized in development and evaluation of the EDAs. I've given you a quick review of uncertainty as kind of a synopsis a la Ernie Hardin. Specific design features were used to address important uncertainties. For all the EDAs, we have a CRM drip shield. The next bullet is in error. We have a CRM outer waste package barrier for all except EDA IV. And, finally, we've limited cementitious materials.

Moving on, for certain EDAs, we've used combinations of high or low thermal loading. We've used line loading and blending. We've limited or incorporated the use of backfill to control humidity. We have looked at waste package energy density effects. And, we've incorporated backfill in some of our EDAs to reduce uncertainty.

Thank you.

BULLEN: Thank you, Dr. Hardin. We'll defer questions for about 17 minutes while Jim Blink finishes his last presentation. How does that sound, Jim?

BLINK: The structure for this talk was suggested by the Board's staff. They wanted me to go through a description of EDA II in a little bit more detail than you've heard, so far, and then talk about some of the trades we've done and how the design might evolve.

The description--I'm going to go very fast because you've seen all that before--we use line loading and blending to reduce axial temperature variations. We used aggressive preclosure ventilation to reduce peak temperatures. Very importantly, we used a very wide drift spacing of 81 meters to facilitate shedding. Only a small fraction of the pillar, perhaps 10 percent, is heated above boiling at any time. So, the large volume of rock remains sub-boiling. Finally, we've limited that duration and the volume of rock to reduce uncertainty associated with altered flow paths. So, we're interested in not seeing fractures clog up a lot of mineral changes. And, additional thermal management techniques that we've used or could use, later closure periods, higher ventilation rates, even wider drift spacings, could result in no rock being heated above boiling, essentially the goal of EDA I.

For the waste package, as you've heard before, we've used two centimeter of Alloy 22 over five centimeter of stainless steel. That eliminated the oxide wedging, gave us a very long structural life, and the thermal management techniques that we've used avoid many of the potential localized corrosion modes of the waste package materials.

Ernie showed you this chart, as well. I've added some of the assumptions on it at Carl Di Bella's request. You can look at them later, but they're the assumptions that go with the NUFT calculation. If you'd go back to that one for just a second? This bump right here is the pulse that happens when you put the backfill on the initial temperature. So, we start out at this point and we run up in temperature.

This is another plot of exactly the same material. This was suggested by Joe Payer of the PA peer review panel. What the pink represents is the time at which the humidity returns to 80 percent for the two different waste packages that are the bounding. If you take all of those trajectories that we showed you on the previous chart and pick the two trajectories that are nearest and farthest from the pink window, that's where they fall. You can see for the one that's nearest, it just barely clips the window; for the one that's farthest away, we have a very long time difference and a big temperature difference between those. I should note that the first drip shield failure that's calculated for the titanium is out there around 9,000 years. So, if you don't have any seepage water onto the waste package for 9,000 years, all of this doesn't mean anything. You really shouldn't look at this curve for anything to the left of 9,000 years if you have confidence that the drip shield will perform as calculated. So, in a sense, it's defense in depth. We have two different things and only one has to perform right to make it work.

The drip shield itself is a two centimeter thick nominally made out of titanium, Grade 7, which is the grade that seems to have the best corrosion resistance in our environments. It's a long drip shield with overlapping sections as opposed to a mailbox that fits individually over each waste package. It protects the waste package from the seepage. It has a long life if it corrodes only from the slow general corrosion. It does provide some rockfall protection of the waste package even in the absence of backfill. It uses a different material in the waste package. So, we should minimize common mode failures of these two engineered materials, although we don't eliminate them; there are some that could potentially work against both. And, finally, it limits the waste package and invert to slow, diffusive transport for a significant period, as Ernie told you.

We then added backfill nominally a couple of feet thick over the drip shields. That establishes the postclosure geometry and that's very important to us to know what the geometry is to start with. So, we don't have to go through a lot of calculations and arguments about when will the rocks fall, what will their size distribution be, what dynamic effects will they have when they fall, what thermal environment will they leave afterwards? We avoid that whole discussion by putting the backfill in.

The second thing it does is it acts as a thermal blanket depressing the relative humidity for a considerable period of time and that gave us an advantage. If I showed you the same plots as I showed you a few minutes ago without the backfill, the temperature and humidity trajectories weren't as favorable.

The ideal material for the backfill would have a high thermal conductivity so that the cladding wouldn't get too warm. It would not wick water towards the drip shield or the waste package from the sides of the drift. It would buffer the water chemistry, perhaps the carbonates that Ernie described to you.

The other thing that backfill does is interesting. If we use a material that doesn't wick very much, the backfill over a breached or cracked drip shield, in essence, is a capillary barrier to water dripping through the crack in the drip shield. So, the water would come down through the backfill and then went sideways across the drip shield and not go through the crack. In a sense, it's like a Richard's Barrier in performance.

We've chosen to use steel ground support and invert structure. I've written here that the type used depends on the ground conditions and Dan McKenzie pointed out to me before the start of this session that I really should say that that's one of the two options we're looking at; the other option being we just go with pure steel sets. We're on a schedule to resolve that by the end of this calendar year.

The ground support will reduce the uncertainties in radionuclide mobilization and transport which are probably bigger uncertainties in the PA than the effect of the chemistry on the waste package corrosion itself. Also, the invert structure will be made of some sort of steel beam structure and the spaces in between it will be filled with something, a granular material that we call ballast, and again we would want to tailor that material to have the optimal properties. One, as in this case, we want it to drain very well, and if possible, to slow radionuclide transport. And then, the other three properties that I cited for backfill also apply.

This one, I won't go through in detail because you can look at it later. Here, I've summarized the uncertainty reductions for the design. I've given some of the assumptions that were used in the calculation. These circles around the drifts which are drawn roughly to scale are the farthest extent of the boiling front into the rock at any time. So, I've shown you the worst point in time for each location. You see they look like they kind of undulate. That range comes from whether you're near the edge of the repository or in the center, if you're in a region of high local percolation flux or low local percolation flux, if you have a very hot waste package right there, or if you have a relatively cool waste package there. So, I've shown the whole range in a relatively small space. That range would occur over the entire footprint, but not in this high a frequency.

This is just a blowup of the previous picture showing you the arrangement of the components.

This one is probably the most important slide in my two talks. There were a lot of questions this morning about EDA I versus EDA II. We recognize that both of those EDAs give us an advantage in reducing uncertainties, and therefore, make it easier to license a repository. The question was why did we push towards EDA II and not adopt EDA I since it got the highest score or the highest ranking in the paralyzed comparisons. This shows you the reason why.

EDA I got that high score in reduced uncertainties, but it was very inflexible. It had small waste packages.

Yes, you could replace the waste packages, but it would cost you a lot of money to go do it after you designed them and started to build them. Similarly, you could skip every other drift that you've drilled and drill additional drifts in additional area, but that is a very large change in the design and the construction. For example, if you put a perimeter drift in now, you've got to think about going to another region and another perimeter drift. So, we tried to find a way to avoid those extra costs and that inflexibility. And, what we do is we look for a design that could use the big waste packages that were economical and would minimize the amount of excavation that we had.

So, this chart shows you the methods, the options that we have. The key part of the slide is the decision of the closure option is not one that we need to make in licensing or right now. It's one that actually doesn't need to occur to the future generations. We start putting in the wastes in 2010, assuming that the site is found to be suitable and is recommended and is licensed. At 2060, 50 years after the start of emplacement, is the first closure option. At that point, we install the drip shields in the backfill.

Over some time, about 20 percent of the pillar, at most, in the worst region gets above boiling; five percent in the better regions. We heat the waste package above boiling for 500 to 1500 years depending on the particular waste package and the result is not susceptible to rockfall damage. But, we don't have to close it here. We could keep going with the ventilation. And, I've just shown you another time that's 200 years out into the future rather than 50 years. And, I could draw other ones. This isn't an either/or; it's a continuum of options.

In Closure Option 2, we close it in the same way as we did it in 1, just later with the drip shields and the backfill. And, in this situation, the entire pillar remains below boiling; none of the rock boils. We heat the waste package above boiling for a much shorter period of time and it's not susceptible to rockfall. Or, if we were really concerned that temperatures above boiling were an issue for these engineered materials for the waste package, we have another route. We could instead choose not to put backfill in. In this case, the pillar remains below boiling, but also the waste package doesn't appreciably exceed boiling. Calculated temperatures are in the range of 102 degrees maximum for the waste package. But, in this case now the drip shield is susceptible to rockfall damage at later periods. So, it's a tradeoff between rockfall damage uncertainty and uncertainty in corrosion of a waste package that's heated maybe 50 degrees above boiling for a few hundred years. Buy, that's a trade that can be done and we'll have a lot more information when we have to make it.

This chart, I'm not going to walk you through. It's just for your reference. It just gives you some of the temperatures and the times that were associated with the three options. I know you'll ask me this specific question. So, I just wrote down what answers I could think of ahead of time.

Let's skip over the cost one. That's one Dan said to get rid of and also the emplacement area and get onto the ventilation. You'll hear more about ventilation from Dan McKenzie a little bit later.

This shows some calculations as a function of ventilation flow rate and we did two, five, and 10 cubic meters per second. We ran three different cases ventilated for 300 years, 100 years, and 50 years. I also put on here for comparison the same calculations that were run for the VA design. The VA design is more effective at removing heat because you have fewer packages in a given drift; so, a lower heat load on the ventilation system in a particular drift. As Bob told you earlier, you can remove about two-thirds of the heat that's generated during the preclosure period in the ventilation stream.

Now, once you have that information at hand, and in fact, if you could suppress that for a minute, I'll show them on this one instead. I've got a replacement slide here and we've got some extra copies of that slide. Because the 60 MTU/acre cases that were shown on the original slide actually were around 66 MTU/acre. Yesterday, we discovered in checking our documents in the QA fashion that we had an error in the original calculations. This shows you the preclosure peak temperature of the drift wall rock for four different cases; two cases that are at 60 MTU/acre and two that are at 50 MTU/acre. That is with about a 90 meter drift spacing. And, two different flow rates; one that removes a half of the heat and one that removes 80 percent of the heat in each case. When you remove 80 percent of the heat and that would take you 10 to 15 cubic meters per second of ventilation, you can hold the temperatures down to the 60s of degrees during the preclosure period and that peak occurs in 10 or 15 years after you emplace the waste and then it decreases gradually from there until closure. On the other hand, if you want to remove half the heat, you do exceed boiling on the drift wall. So, clearly, if we were trying to preserve this option to evolve towards something with non-boiling rock, we would have a ventilation rate that's somewhere above that 5 range and more in the 10 range.

Then, the other columns show you for each of these cases, this is 50 years of ventilation, 75, 100, and so forth and this shows you the postclosure temperatures that occur at any time at the future, the highest temperature that ever occurs on the drift wall. And, I put in bold the temperatures that are sub-boiling so you can see some cases that work. For the case of 60 MTU/acre, the EDA II case, you can see for 125 years or longer of ventilation, we don't exceed boiling. Now, these calculations are the LDTH, one of the component models of the multi-scale model that was shown on the previous chart. With the new calculations, we've got 125 years and I showed you 200 years on the previous charts. I didn't update the previous charts. They were based on the calculations that had a smaller drift spacing. This is the drift wall temperature, not the waste package, which is very insensitive to backfill.

For two of the cases, the 200 year case for the 80 percent removal and the 50 years case for the 50 percent removal, I've shown you the time that the waste package itself is above 85 degrees C. You can see that that number is in the neighborhood of a few thousand years depending on which situation you use. So, I think this might answer the question that Dr. Cohon asked earlier this morning about what happens if you keep it open longer? With this chart, you can kind of see what you gain as you do that.

The recommendations that we've got for design refinement are in our report. They're in Chapter 7 of the report and I've just made a synopsis of them here. So, I'll run through them fairly quickly because I know you can go back to them. First of all, we want to establish a design basis heat output for the waste packages. Bob Dulin told you the numbers wee assumed for these EDA calculations and they were based on certain degrees of blending for the different designs and we need to firm that up with more detailed waste stream calculations as input.

We want to revise the modular design and construction study that was done for the VA design for the EDA II design to include blending and also more modularity in the subsurface construction. Right now, we have modularity in that we have a construction sight and an emplacement site, but as you go to something with more aggressive preclosure ventilation instead of two ramps and two shafts, you have two ramps and maybe six or seven shafts. Now, you can think about when you build them and how you set the thing up. So, it's more complicated, but it is an opportunity, as well.

We want to compare the costs and benefits of ventilation and other thermal management techniques. One of those is something we haven't yet mentioned today and that's segregating different kinds of wastes in different drifts. Since we have relatively independent drift behavior, we don't need to resort to the multi-drift thermal codes to calculate what's happening. We could designate a drift for the Navy wastes. We could designate certain drifts in the repository to take high-level waste glass. We could determine some other drifts for the commercial fuel. As long as we go far enough ahead, when the waste comes, we could put it in its own particular type of drift. That's something that we need to look at.

We presumed a 50 year preclosure period for all these calculations, but we don't want to preclude a longer period of ventilation. So, for the detailed design, we want to make sure that we take the right steps.

We want to eliminate the small waste package designs. In the VA, we had some 12 PWR waste packages. With the blending, we got the number of those packages down to around 200. So, it seems like it would probably be more cost-effective to forego the design effort and just put those small amount of assemblies in derated packages that just have a space filler in the empty slots. Of course, we've talked about the waste package design and we need to continue testing and modeling the materials. We want to consider canisterizing spent nuclear fuel that we know doesn't have intact zirconium cladding. We know 1.25 percent of the wastes we'll get will have cladding made of some other material and then maybe .1 percent has some pinhole cladding. If we just take those assemblies and put them in a canister and slide the canister into the basket, we could gain a lot of performance at a relatively minimal cost. A similar situation exists with respect to the high-level waste pour canisters which are made out of 304 stainless steel. Perhaps, coating them with a ceramic or a thin layer of corrosion resistant material could make those have higher performance.

We recommended going to a steel ground support to minimize uncertainties associated with the cementitious materials. We recommended developing a drip shield design using the titanium, Grade 7, as the initial material, and then once we've proceeded through the SR and possibly the LA processes, we can go back and try to optimize that. Since we don't need this component until at least 50 years in the future, we don't need to rush to try to optimize it within the real tight SR schedule. We need one design that's defensible, but it may not be the design that we would ultimately build. We could probably come up with something better or cheaper over the period. Finally, we have already accomplished the last one, the evaluation of EDA II without backfill. We did that evaluation and have documented that and the conclusion was the backfill gave us a better ranking in the various areas than the no backfill.

Finally, the SR design and science activities, we've been re-evaluating the scientific and engineering data. I think it was referred to earlier as reprioritization. That work is ongoing. Also, we've been looking at the drift scale tests. Could we modify this test to make it more appropriate in support of EDA II, for example? And, you'll hear more about that later. The bottom line of it is we probably don't need to; it's already closer to EDA II than the VA and it's a model confirmation test as opposed to a prototypical test.

The summary is the M&O has recommended EDA II to the DOE. It has a greatly reduced uncertainty compared to the VA design. It's calculated dose rate is well-below the screening criteria and it's extremely flexible to react to performance confirmation data without causing extensive redesign or construction costs. That was the real difference between EDA I and EDA II is we tried to ask ourselves the same questions that Dr. Craig was asking earlier and that drove us to a variation of EDA II as a cheaper version of an EDA I type of design.

BULLEN: Thank you, Jim.

To facilitate answering questions, I would kind of like to ask Dr. Hardin to come up to the microphone up here and Kevin and Bob to play tag team on the microphone right there so that we can come back to questions that may be for this entire session.

I have deferred to Dr. Parizek from long ago and I'm going to ask him first if he'd like to ask his question since he agreed to defer.

PARIZEK: I had one left over from Kevin Coppersmith, but it was sort of asked and that's a combination of safety and the licenseability combined. And, we sort of have an answer. It seems like it was licenseable. NRC is not going to give you a license for something that's going to kill people in a sense of doses, but safety, does that imply like rockfalls, workers' injuries underground? You know, is that also part of that? That's a question, I guess, for Kevin or anyone in the program here. By lumping them, right now I think the public's perception of this will be, hey, you know, safety is not an important issue here because it wasn't selected in the design and safety to them might not be understood in the context of how you're just defining it here.

COPPERSMITH: I'll go ahead and answer. Number one, the issue of licensing and safety, I think the point that was made is an important one that not only do you need to have doses that are below the standard, but you need to be able to demonstrate that. So, the demonstrability comes in issues of uncertainty and engineering acceptance and so on. For people who have been through licensing, you know that, in fact, you need both parts of that equation to be able to get a license. You need to be able to demonstrate it, as well as it needs to be adequately safe.

The issue of worker safety came out in our criteria in the construction operations and maintenance issues. This is where you're dealing with things like handling issues, the operations, the length of drifting, for example, all the worker safety issues that are related in many ways to the amount of activities and the nature of those activities are part of the construction operations and maintenance criteria.

PARIZEK: One of them is really is for Lake Barrett, I believe, if that's fair.

BULLEN: Well, Lake is here. You've got the floor. Go ahead, Richard?

PARIZEK: It had to do with the time slippage. In January, I asked about the milestones and there was obviously good reason for the program to be moving forward in a timely manner. But, if slippage occurs, it sort of relates with Dr. Mifflin's concerns, perhaps, as well. That is what do you let slip? Surely, you can gain a lot by having more time to complete tasks providing those tasks are aggressively being undertaken. So, any experiments that take time like the heater test, you'll gain some advantage of having maybe the second, third, or fourth year of data and the chance to chew on it. That may be true with tracer experiments and other things of that type. So, we could gain something by having more time in the program for pursuing those things that take time and then give up on things which--like you say, above ground type activities that aren't quite as critical and maybe you wash them and get them done when you need them.

But, it's not the same as like underground experiments; you have to let the clock pass in order to have the results.

So, time slippage, how would one decide again what's in and what's out of experiments that need to be carried out if you do have more time?

BARRETT: We're going through this prioritization process now. We want to use whatever money we have to the most productive use toward national decisions. We have sort of prioritized the decisions. We believe that the site suitability recommendation decision is the next major decision and that's the one we'd like to focus on the most and defer license application in lieu of the site recommendation. So, this would cause us to focus on the postclosure issues, such as the national systems, and decrease the focus now on, say, surface preclosure, engineering things, and how to handle fuel, etcetera, which are all part of license application, to try to hold on to the site recommendation as early as we can. If we can make that schedule or not, we don't know. We're going to have to look. We want to have a credible, sustainable site recommendation for all; for the public, for the Board, for the NRC, for the Governor, the State legislature, everybody. And, we want to see if we're going to be able to do that or not. And, we don't know yet until we finish the process.

PARIZEK: The question about the draft impact statement that's due out, does that include temperatures that are associated with some of these design alternatives? I guess, I don't quite know how the environmental impact statement will consider temperature and there must be some temperatures assumed. Are they close to any of the ones that we've been hearing about today?

BARRETT: The DEIS will have a range; a low, medium, and high temperature range. Exactly the metric tons per acre, I don't know. I think someone else may. Does one of you folks know?

BLINK: We went all the way down to 25 MTU/acre in EIS. So, we've bounded the range between the VA and lower than EDA II. There was an intermediate one. I don't know if it was 60 or 50, but it was in the right ball park.

PARIZEK: So, it's bound to be covered somehow. I guess, ventilation might also be in there in terms of length of time you might ventilate because of the option to ventilate longer may have some consequences?

BLINK: I don't think the EIS calculations had ventilation in their thermal calculations. I think we're talking about in the OO planning activity to do an additional EIS case for whatever design is selected.

PARIZEK: Well, I'll ask a question on buffers. I didn't know what kind of buffers were being considered. I thought it was some marble that might have been the buffer.

What are the buffers and the purpose of the buffers?

BLINK: The bicarbonate in the water and the nitrates in the water act as a natural buffer already. So, that's what I was referring to as--when we take J-13 water and concentrate it, it's not very aggressive because of the buffers. If you take the buffers out and you make yourself a solution up that's got some of the more aggressive materials without the buffer, it's a more difficult solution to resist corrosion-wise. So, it's the natural buffers.

BULLEN: Leon Reiter had a deferred question, also. So, I'll defer to him now.

REITER: I think Jim started to answer that. But, this sort of relates to the comments that Dr. Cohon and Dr. Knopman made. That is about the inherent flexibility in going from hot to cold in design level in EDA II. And, it seems to me that that flexibility is dependent upon another flexibility and the flexibility to extend the period beyond 50 years. Now, if I understand that, I don't know if we know that flexibility will exist or not. That flexibility of extending may have some political components. So, doesn't that in some case weaken the flexibility of going from hot to cold in Design 2?

BLINK: Thermal management is based on a lot of different variables, as Bob Dulin tried to describe to you. We have probably five or six knobs that we can turn. The ones that we turn for this was the time because if you turn a knob that's associated with the design, you have to make that decision up front so that you build the thing with the higher ventilation rate or you build the thing with the surface storage. You build the thing with smaller waste packages. All of those things are decisions you have to make and they force you into a corner. The time knob was a knob that we could turn and retain flexibility for the next generation to make the decision after the confirmation data within.

REITER: The only thing I--I don't want to repeat myself, but isn't that an assumption that you will have that flexibility at that time. There may be other considerations; say, well, gee, it would have been nice, but we don't have that flexibility? So, it's dependent upon somebody in the future being able to make that--to have that flexibility. Now, you would assume it is in 50 years. Obviously, there's some assumptions besides 50 years.

BLINK: It's actually probably the other way around though, Leon, is we'll have to take a case to the licensing body of the NRC and say that we're ready to close. So, we'll have to prove that we're ready. If we don't prove it, the default is to keep it open.

REITER: And, there are no policy implications in the amount of time you want to open this?

BLINK: You said the word "policy". So, here comes

Lake.

BARRETT: The license application, whenever that is, is going to have to set out the safety case against the NRC requirements and we're going to specify a time. We will specify the shorter time; nominally, you know, 2060 and now maybe it's 2050--I don't know the time--and make the case. That will be the harder safety case to demonstrate through the rigorous process. Then, we will also say, though the NRC will give us no--I don't believe they'll give us credit for it--that you could keep it open longer, things will get better. They will say, well, that's very nice, but show me your safety case for what your--or which would be the shorter time period? Now, if it's 50 years or if it's 10 years after closure, we need to work that detail out.

BULLEN: Thank you, Lake. Albert Sagüés?

SAGÜÉS: Sure. The time/humidity/temperature curves are crucial to demonstrate or to hope that the waste package corrosion--will have a good chance to survive. And, I think that it's important to make sure we understand how they are made. In your second presentation, Jim, you have figures 5 and 6. Just to go through it, in Figure 5, you show the temperature and relative humidity paths and you show that for the EDA II case, there it is. Now, there's a number of parts that falls within the yellow zone and almost get very close to the pink area and, as a matter of fact, quite a few of the others, the other bifurcation, also seem to be close in the yellow area. However, in the next one in #6, what appears to be a worse type of case does not seem even to touch the--what would be the yellow area. Am I seeing that correctly?

BLINK: Yeah, I haven't plotted the yellow area on this particular figure. This is just the red area. So, the yellow area would be farther to the left than the existing red areas.

SAGÜÉS: It says "time humidity returns to 80 percent" and that would be the 80 percent in the yellow area, I think.

BLINK: The yellow area is--

SAGÜÉS: --50 percent. Right, right. So that it's not --okay. Now, coming back into the previous one, to #5, okay, now when we had the previous presentation, the Hardin presentation, I guess that you have shown two figures, one for the EDA II case and one for the EDA I case. Now, in the EDA I case, most of the parts were away from even the yellow zone. For this case, and a good number of them go through the yellow zone, but you indicated something at that time that this particular--at least some of these--one of the branches corresponded to situations in which moisture would travel lengthwise through the drifts. Did I understand that correctly?

HARDIN: That was not exactly my intent. I pointed out that the calculations which I had shown you were made using a method that did not explicitly take into account the movement of moisture in the gas phase along the access of the drift.

SAGÜÉS: Oh, did not. Okay, for both cases. For the EDA I case and the EDA II case, both figures were comparable to each other?

HARDIN: Yes.

SAGÜÉS: Completely. Now, in that case, it would look like the EDA I case was vastly superior to the EDA II case because it totally avoided even the extended, fairly conservative regime assumed by the yellow area. Is that right?

HARDIN: That's generally correct. What I was--

SAGÜÉS: If you look in the left figures, 10 and 11, they have the presentation.

BLINK: The idea on this one is the first drip shield failure on this is at 9,000 years. Until the drip shield fails, you can't have the yellow situation.

SAGÜÉS: Well, okay. That goes to another issue I wanted to bring up. And, that is like how good of a drip shield is a drip shield especially if it is a conceptual drip shield that has not been designed yet? The question is, of course, I'm sure that many engineers here could think of assorted ways in which water could find its way either as liquid or through the vapor phase in the area immediately underneath the drip shield and elevate the humidity and so on and so on, even though you may not have your dripping contact.

BLINK: The vapor phase is not a large concern because it doesn't have the dissolved minerals. You know, when it condenses, it's fairly pure water. Drawing this yellow rectangle is a difficult one because it's a partially saturated material. It's hard to know what you've got. Remember that for crevice corrosion to occur, we need the crevice geometry, we need the minerals, and we need the temperature and the humidity. I think from both of these designs, we have at least two of the four necessary components being missing. Maybe for an EDA I, three of the four are missing, and for EDA II, two of the four are missing. But, we don't think that there will be a crevice corrosion issue with this. We're obviously still working on it, however.

HARDIN: If I could just elaborate on your previous question. My point in making that statement about the calculation method was that I feel that the relative humidities that we'd shown for EDA I might be in some sense lower bounds.

BARNARD: This is a question for Kevin Coppersmith. Most of the uncertainties are related to high temperatures and these uncertainties are scientific. As I recall the integration group that you used to rank the design alternatives was composed primarily of engineers. My question is would the judgment shown in your Slide 12 be significantly different if you had an equal number of engineers and scientists?

COPPERSMITH: I think, number one, the process is not one of counting noses, as you know, and not one of one person/one vote. The issue is when we deal with uncertainties, I think from my standpoint, is the core team which is looking at those and making evaluation. Are they aware of the issues? So, we spend a lot of time in the first workshop and in the second workshop and then periods in between making sure that the team was very much aware of those. For example, Ernie Hardin was part of the LADS extended team, the core team, the extended team. The presentation that he's made here today he made at our first workshop, you might recall, talking about the uncertainties. He didn't talk about how the EDAs would deal with them because we hadn't done it yet. But, these types of considerations, as well as this Board's written materials, the USGS and other groups have made. These issues are very high priority. I think, the core team is very aware of those, both those that deal with the issues related to corrosion, localized corrosion processes, as well as thermal and coupled processes. Again, someone coming from outside the project dealing with elicitations on these basic issues, these are very high priority issues; the issues of coupled processes, uncertainties, and what can be done about them. So, I don't think it really dealt with the disciplines involved. I think it basically dealt with people's ability to understand what they were, what the uncertainties were, and whether or not we could avoid, mitigate, or just live with them.

BARNARD: Thank you.

BULLEN: Thank you. Russ McFarland?

MCFARLAND: Ernie Hardin. Ernie, you're aware that just within the last month or so the results of the mapping of the east-west cross strip have been made available. Indications are that the zone below the middle, non-litho, in which all the thermal tests have been run could be considerably different, both in thermal, hydrologic, and mechanical properties. How have you factored this in as an uncertainty since current plans do not call for testing of the non-litho probably until 2001?

HARDIN: One way that we have factored that in is through low thermal loading. Another way is that in evaluating temperatures that would be associated with low thermal designs, we have not resorted to--we've used different models including some which are "conservative" in that they don't require hydrologic processes that involve mass transport. In other words, a conduction-only model that may take some consideration for dewatering of the rock then can be used to predict temperature.

MCFARLAND: Your EDA II basic design is based on thermal premises obtained from the single heater and the drift-scale heater tests. Your 81 meter spacing between drifts, your assumption that the pillar will drain freely avoiding some degree of refluxing, how do you rationalize that?

HARDIN: Well, let me repeat the argument I just gave you. To come up with the 81 meter drift spacing, we developed a position based on a model in which it was a thermal conduction-only mode where we had also allowed--we took into account the insitu ambient matrix saturation. So, there's some water there that will evaporate off and mobilize heat. We did not include the hydrologic effects; for example, the ambient percolation flux which is always present as a boundary condition on the problem or the heat transfer effects from water that move out as vapor, condense, and then be shedded and move elsewhere in the system. What I'm getting to here is the first two effects, that is heat transfer by thermal conduction, is far less uncertain than transfer by moving of liquid water through fractured rock. And so, for EDA II, for example, that drift spacing was something we came up with using the special type of model. And, that model in my view applies equally well to the lower lith or the TSW-35 hydrostratographic unit as it does to the middle non-lith in which we've done these thermal tests.

Yeah, I could elaborate on what we know about thermal properties or thermal conductivity of the rock. Thermal conductivity is a spatially variable quantity, but it doesn't vary nearly as much as the bulk permeability of the rock mass. Nor does it exhibit the same scale dependence. So, it's a far more robust input data to these predictive models.

BULLEN: One more quick question from Don Runnells and then I'll have the Chairman's prerogative of last question and--

BLINK: Well, I can add to Ernie's answer for Russ? The bounding model that Ernie described was used to select the dimension, the drift spacing dimension, but the thermal-hydrology calculations that we've shown you use the best available property for all of the units with different properties for the lower lith and the middle non-lith and, in fact, different across the footprint, as well. When we went to those models that had more physics in them and more uncertainty, we had less of the rock above boiling than we did in the bounding model that Ernie described.

BULLEN: Don Runnells?

RUNNELLS: Could you go back to Slide #5? My question simply is how certain is the yellow box? I don't have any feeling for the uncertainty of the size and the location of the boundaries of that yellow box.

BLINK: 125 comes from evaporated water off the metal and we could not maintain an aqueous film above that temperature. The 50 percent humidity comes from basically-- and, humidities below that, it goes totally dry. The 85 degrees C was extrapolated from NRC measurements, I think, that were around 95 C, if I remember right, at the condition they had and we extrapolated it. It's probably a lower bound --that real number is probably higher.

BULLEN: That's a very weak extrapolation. I saw that at the center a couple of months ago and asked him about that and I think the data are the data at 96. They're not at 85. So, that 85 is a real tenuous for my expectation and perhaps overly conservative because I don't think you can do that, but that's just my opinion and I'm only one person. But, I understand why you drew the box.

BLINK: Yeah, the box is probably bigger than it needs to be. We don't think the box would be any larger than shown.

RUNNELLS: The lower boundary of the 85 degree boundary then is the most uncertain thing on that box?

BLINK: Yes.

BULLEN: Okay. Sagüés, one quick one and then we've got to call it quits here.

SAGÜÉS: Yeah. The critical temperatures for crevicing or for pitting and the like are empirical concepts which are based on very short-term testing, extremely short testing compared to the service lives that we're trying to achieve over here.

BULLEN: Good point, okay. Last one; yes/no question. You have oxide wedging in your modeling as going to stainless steel would reduce that uncertainty. Do you have an oxide wedging failure mechanism in the waste package degradation model that uses that or do you still fail it with any kind of perforation that has so many centimeter by so many centimeter patch that's failed, and if you don't have oxide wedging as a failure mechanism, then why do you care about oxide wedging? Yes or no, do you have oxide wedging in the model?

BLINK: Oxide wedging is not in the model and we don't want to have to put it in.

BULLEN: Okay. And so, if it gets--the followup question is how big is the patch when you fail it then?

BLINK: About six square inches.

BULLEN: Thank you.

BLINK: About six inches by six inches.

BULLEN: Okay. I will cut it off now. I would like to thank the presenters in this session. We have one more section of this session on subsurface design. I would like to reconvene in eight minutes at 3:55.

(Whereupon, a brief recess was taken.)

BULLEN: --from Nye County and he's going to give us a summary on the Nye County Workshop on Alternative Repository Designs followed by Repository Subsurface Design by Dan McKenzie from the M&O.

Mal, it's all yours.

MURPHY: I'm going to be real brief because I want to save as much time as possible for Dan McKenzie, the speaker who will follow me.

I just want to very quickly go through the objectives and the conclusions of the Nye County Repository Design or Naturally Ventilated Repository Design Workshop that we held last December here in Las Vegas. Based on some work that Parvis Montazar had principally done for Nye County, it became pretty clear to us a year or a year and a half ago that natural ventilation would provide some significant advantages for long-term waste isolation for the repository. In discussing these issues one day at the high-level waste conference with Lake Barrett and some Nye County folks, Lake suggested that we conduct a workshop on the issues. Sounded like a good idea to us and we did that last December 1 and 2 in Las Vegas. Nye County was the sponsor of the workshop; Department of Energy was not a co-sponsor, but they were extremely cooperative with us in the whole endeavor. Paul Harrington from DOE was our liaison and was very, very helpful in helping us organize and schedule the workshop and recruit speakers and encourage attendance. So, DOE was right there with us the whole way.

We had several objectives that we wanted to cover during the workshop and I've laid them out here. I just want to touch on them very, very briefly. The principal one, I think, was to identify the design or operational alternatives to avoid in order not to preclude long-term natural ventilation. I think I can safely say and I think you can conclude on your own based on what you've heard earlier today that that objective was clearly accomplished. I think, DOE has committed, as they did at our workshop, not to do anything or not to present any design to the Nuclear Regulatory Commission in licensing which would preclude the flexibility to go to this kind of long-term natural ventilation. So, to that extent, if no other extent, I think the workshop was very successful.

I'm going to skip through the rest of the material and I'm just going to go straight to the conclusions and recommendations because, like I said, I want to save as much time for Dan McKenzie, who incidentally was one of the principal presenters at the workshop in December, as was Dan Bullen from the Board.

These are consensus recommendations which you will find in a summary report for the workshop. The report is available here on the table, I think, in sufficient numbers.

I hope everybody on the Board has been given a copy. The report is also available to download from the Nye County website at www.nyecounty.com.

The consensus conclusions were that at a minimum continued monitoring of this ventilation should continue through construction; large-scale natural ventilation experiments should take place; comprehensive simulations of heat and moisture removal should be conducted; and appropriate testing to validate the models used. I think I can safely say that all of those conclusions and recommendations are either being accomplished or are planned by the Department.

BULLEN: Thank you, Mal. If you'll just stick around and be close, we'll ask questions in a couple minutes.

The second half of this presentation is given by Dan McKenzie and he's going to talk about the repository subsurface design from the M&O perspective.

MCKENZIE: Okay. I don't get to talk to the Board very often. I'm glad to be here to be able to say a few words. Unfortunately, I have to say a lot of words in a short time. I've got five topics here. I had a suggestion from Carl Di Bella of the staff to shorten a couple of them and I'm going to do that and I'll tell you which ones to skip when we get along to it.

We'll start right into ventilation. The first two topics actually are really a discussion of how the VA design which a lot of you are pretty familiar with differs from EDA II. Okay. The big difference, as we've seen a bunch of times and I'm not going to spend a lot of time on it, is that the primary difference between VA and EDA II is the amount of air flow that goes through the emplacement drifts. VA had a very low, almost a leakage type of flow, and EDA II requires essentially a minimum of two cubic meters per second which is, say, 4200 or 4400 cubic feet per minute of air flow in order to maintain the thermal goals. There's a lot more waste in the drifts in EDA II. So, you have to have some amount of ventilation to moderate the temperatures.

You can accomplish below boiling conditions in the preclosure if you crank that up to 10 cubic meters per second which is in the 22,000 cubic feet per minute range. If you want to say postclosure forever below boiling, essentially with EDA II layout and waste package configuration and areal mass flow, you just increase that or increase the time and leave the flow rate at 10 cubic meters per second and about 200 years will do it. Jim with a different model came up with a slide with a shorter period, 125 years or so. There is a fair amount of variability between the models. This is the conservative type model that Ernie and Jim were talking about, conduction only, no thermal-hydrologic consideration. So, it's pretty conservative when it predicts temperatures are usually kind of high.

Okay. The VA had essentially very low flow in the drift. So, it had about 280 to 300 cubic meter per second total air flow capacity. That was all the air you could stuff through the VA layout. It only had two shafts and two ramps. In order to put this kind of flow through all the drifts, the emplacement side needs to have a capacity in this range. There's a lot of flexibility in that number. There are non-emplacement flows included in that 1700 cubic meters per second. But, it's a little over five times, almost six times, the VA flow rate. It takes seven shafts plus the two ramps that we already have in order to move that kind of flow to get down into the repository and back to the surface.

Peak power requirements, in the backup to these charts you'll see the simple formula that we use to get this 6700 kW. It's about a 9,000 horsepower. It doesn't take credit for things like positive natural ventilation pressure which should be a significant power saver really when we get down to taking credit for it.

Okay. This is a really gaudy, ugly color picture of the layout that I have. I wanted to draw a little bit on this one. So, I brought a viewgraph of it. Pardon my color scheme. Okay. All I wanted to do was show the shafts here and a little bit of the differences. One of the things that you'd notice if you're familiar with the VA design is that there's kind of an annex here. The VA design stopped right about there. So, we've got a little piece to the north that we added on because we needed more area. They talked about their multiple shafts. There's an intake shaft there, one there, an exhaust shaft, exhaust shaft, exhaust shaft, exhaust shaft, and development intake shaft there. Plus, you have air flow down off the ramp during development, down the north ramp during emplacement. So, you have more shafts so that you have more ability to move more air. Those are the primary big differences. One other one is in this area. See, there's a double line there. There are two exhaust mains there instead of one and that's because if you remember the VA we had, we tried to capture the hot air in a set of exhaust ducts in the single main exhaust. But, since the flow rates are a little higher now, they're a lot higher, duct work really is not feasible; it would be way too big. So, we went to the two main exhausts. We still have a lot of work to do in that exhaust area; how to regulate the flow, how to segregate the hot air from the cold air, or whether to do that at all. So, we have still some head scratching to do about exactly how we're going to exhaust the air. We feel like the EDA II was a valid concept, but we need to do some work in that area.

The next one is preclosure conditions and again the emphasis here is on what's different, where were we, and where are we going in terms of preclosure conditions? Okay. We already talked about higher ventilation flow rates. Drift temperatures generally lower than the VA, but that depends on the flow rate. You get about the same temperature in EDA II with two cubic meters per second as you had essentially with no flow in the VA. So, in the low flow rate for the EDA II, you have about the same temperatures you had before, at least at the exhaust end of the drifts. A lot fewer replacement drifts. You notice the drifts are much further apart. If you're familiar with VA, the spacing was 28 meters; now, it's 81. You get all the waste in about half the drifts by putting the cans in essentially end-to-end. You should have increased moisture removal in the near-field because of the large amount of flow through the drifts and the fact that it's Mohave Desert dry kind of air, it should be generally very aired conditions in the drifts and moisture removal at least in a transient way until you draw enough moisture out of the rock far enough back that it sort of reaches equilibrium. It shouldn't be a forever process. It eventually should reach an equilibrium, but early-on, at least, you should remove moisture from the near-field and then you have these line loaded emplacement drifts.

Okay. Lower areal mass load, what that translates to is more area. If you have the same amount of waste and you want to spread it out, it takes more area. 60 versus 85, this one has about a 1,050 acres required emplacement space. The VA was 747 or so. This is one that we touched on just a little bit earlier this morning; the radiation levels in the surface of the package are a little higher than they were because the barriers are thinner. So, if you remember the VA concept, we had already had a pretty heavy transporter, a total load of just under 240 metric tons loaded on eight rail wheels. That's a pretty good load. If we just simply increase the shielding on the transporter to offset the higher dose from the package, we'd have a much heavier transporter, heavier than we want to mess with. So, we're looking at a couple of ways of dealing with the higher radiation so that we don't--we still have a safe operation without having a transporter that weighs 300 or 400 tons.

Larger area, several additional shafts. We talked one additional exhaust main, and then a fairly important one, placement of drip shields and backfill at closure. That gives you another real good reason for keeping the emplacement drifts open and maintained all through the preclosure because you know that if this is your closure strategy that you're going to have to have access to every meter of every drift. So, you have to be able to have a maintainable facility design whether it's going to last for 25, 50, or 300 years.

Okay. This is one of them we're going to skip.

Let's go about three charts ahead.

Okay. The drift stability panel was convened to provide input on the ground support design to the repository subsurface design team. Now, the panel has a preference for what's called rock reinforcement. Generally, two kinds of ground control are reinforcement where you drill holes and put, say, grouted bolts or some kind of rock bolts in the rock to actually sort of reinforce the jointed rock mass. The other concept is ground support which is essentially liners that you put in the drifts and tighten up so that you just support the rock and you don't have any active reinforcement out in the rock.

Our current and planned analysis should provide a basis to make a decision on this recommendation as to whether we're going to go with purely bolts and mesh and steel in the bad areas or all steel or maybe even a combination. The stability panel actually talked about an option where you might have some of both, grouted bolts and steel sets. By the end of the calendar year, we should have these analyses done or far enough along that we can make a call on what ground support system we want to recommend for the SR design and move forward.

I think the last one is--we're going to skip most of the performance confirmation one and skip about the first three or four--let's see, skip two more. This is just the status of performance confirmation plan. We already have a performance confirmation plan in place, but obviously since the design has evolved somewhat, we need to adjust the PC plan to match the design that it's trying to confirm the performance of. EDA II has different geometry and more engineered barriers and materials. The second one is fairly important. The ventilated drifts are no longer going to be very representative of potential postclosure conditions because of the fact that there's a lot of air movement through them. The temperature is artificially lower, the humidity is artificially lower. Maybe, one way to mitigate that is to have specialized test areas, an area or two areas in the facility that we try to do as much as we can to make them look like the postclosure conditions and then we'll ventilate them. You put heaters in them or packages and backfill and drip shields to try to simulate as much as you can the postclosure situation to get an idea of what's going to go on because all the ventilated drifts aren't going to tell you much about that. Updating the parameter selection is being tied to the principal factors which you're familiar with. Those are the important things that drive the performance and the TSPA itself.

The type and extent of PC testing will probably change. The expected changes are, at the very least, we'll revise the observation drift network. Now, if you're familiar with the PC plan and VA, observation drifts are drifts that are above the block by 15 to 20, 25 meters and they are observation galleries. Since you can't go in the emplacement drifts, you have alcoves off of the observation drifts. You drill holes down into the rock mass between the pillars and in the pillars between the drifts and you install instrumentation to see what's going on and where water is moving and what the temperatures are and that sort of thing. So, the observation drift network in VA, the first pass through didn't incorporate the cross-drift because the cross-drift wasn't built yet. So, now, the cross-drift is there and it's in the plan where the observation drifts would be. So, we're going to incorporate that into part of the observation network.

We need to test these additional EBS components and we have backfill and we have drip shields that weren't in the PC plan before. There's the special test area I was talking about to try to simulate the postclosure conditions. And, we had a fairly extensive five--five cross-drifts, five observation drifts for an area of 740 some acres in the VA design. If we can, we'd like to reduce that consistent with the objective of getting statistically significant data across the block so that we don't leave any areas out. But, we'd like to reduce that to the extent we can to sort of streamline that program.

I think that's all there is.

BULLEN: Thank you, Dan. Questions?

KNOPMAN: Could we look at Slide 6, just your layout? In the VA design, if I'm not mistaken and maybe I am, the main exhaust was--it's a light blue line or turquoise line that runs the length of the--right--was actually below the emplacement drifts.

MCKENZIE: It still is.

KNOPMAN: It is still below?

MCKENZIE: Yes.

KNOPMAN: Okay. Do you want to explain that because I still don't understand why if--I mean, I thought hot air rises. So, I'm trying to figure out how the hot air goes down.

MCKENZIE: This room is a good example of that. Okay. The drift is below because of a judgment that we made--let me back up here just a second and we'll have a little bit of history. The drift used to be in the plane of the block. It used to intersect all the emplacement drifts back in what was called the advanced conceptual design. We said, well, gee, that's a bad idea because we have to poke a hole through it every time we drive an emplacement drift. It takes up space because you can't put packages there. So, we said, okay, we'll take it out of the plane. So, it's got to go above or below. We said, all right, what if we put it above, what if we put it below? If we put it above, we thought it might play a part postclosure hydrologically because it would be a collector. Remember, that drift has to have vertical connections down into each emplacement drift because that's how the air gets out. So, we said, well, water might find its way into the exhaust drift. It's downhill to the north this way. Any water that gets in that drift anywhere is going to run to the north. It will only run until it finds the first hole and then it will go down. And, the emplacement drifts are down below there where the waste packages are. So, we said, well, maybe that's not such a hot idea to put it above because of this possible long-term postclosure hydrologic concern. So, we put it below just because it takes it out of the hydrologic picture. Now, it does cause the air to make a 10 meter detour downward, but it goes up 400 meters after that. So, you're not going to discourage much in the way of natural draft. It's not a big loss. We just thought it was a good idea from a hydrologic standpoint. So, that's why it's there.

BULLEN: Alberto Sagüés?

SAGÜÉS: Hi. Did I understand correctly? You said that most of the thermal calculations did not take into account of the effect of circulation, did not take into account the water movement for the thermal--

MCKENZIE: Jim might help me with this one. The ones that I run in subsurface design, that my analysts run, use ANSIS as a basis and they use the air conduction-only models out in the rock. But, as Ernie was indicating, there is some accounting taken into the fact that there's already water in the rock, and as you pass through the boiling point, you boil that water away and a considerable amount of energy is lost to the system because of the vaporization of that rock. That is taken into account, but not water movement and the associated cooling of the drifts.

BLINK: There's three calculations that were done. Dan's calculations which very well handled the movement of heat in the air that's being transported; the NUFT calculations which don't handle that, at all, but just assume the heat source is less based on the parametric calculations from the first set; and then, the calculations that the M&O sponsored at the University of Nevada-Reno by Professor Danko which do both. He has the fairly elaborate scheme using the thermo-hydrology code and a ventilation code and couples them together. We've taken those results and we compared those results to the other two codes to make sure that we're doing that overbounding on the other two codes.

SAGÜÉS: Okay. So, the result of the comparison was what? That you were bounding it right?

BLINK: Yeah, it was favorable.

SAGÜÉS: How deep into the wall of the--after, for example, 50 years of air circulation, how deep into the wall of the drift have you incorporated water, basically?

MCKENZIE: That's an important question. I think in the ESF we have data that suggests it's at least a couple of meters, but I don't know much more--I really don't know how far it's going to go after that. Jim, do you know what the data looked like? A couple of meters is where we're at after, say, five or six years.

SAGÜÉS: Now, doesn't that have a bearing on whether the design results on water boiling or not because you start with drifts now that have an aura of two meters with no water. We have all this consensus about the temperature of the drift wall being below 96 degrees and the like. Wouldn't this be a fairly important factor to take into consideration because maybe things are better than what we think they are?

MCKENZIE: There's a lot of things that could make things better than what they are. We tend to be pretty pessimistic when we do these models, but you're right. I think if you drive enough rock before you put the heat in, the model would look a whole lot more like the ANSIS models that my guys run with ventilation than they would the thermal-hydrologic models because some of that water is already gone by a different route. But, you're right, that could be important. It's not something that we model right now. Right now, the heat goes in there the day you make the hole. There's not any pre-emplacement effects taken into account.

SAGÜÉS: It looks to me like a fairly major--I mean, two meters extra, that's like making--what is it? It's like nine meter diameter drifts from the--as opposed to five meter diameter or something to that effect.

MCKENZIE: It may be significant. I think if you calculate the amount of water in that two meter aura, as you say, it could be a significant amount of water which could be important and something, I guess, we'd look at later on. We're really kind of in the infancy of being able to model this very well. Dr. Danko's model is going to help us a lot once we get it qualified and get it in our system so we can run it. It will give us an idea of that and help us calculate what the actual at emplacement conditions are.

BULLEN: Any other questions from the Board?

ARENDT: Any thought been given to recovering the heat from this ventilation process?

MCKENZIE: Not in any active way. What we're going to do is get free power essentially. The way that we always lay the system out is so that the natural ventilation that you get as a result of the big difference in air density between the intake and the exhaust is always in your favor. So, we'll get free ventilation pressure essentially. But, I've seen presentations on belt and wheels and sort of things that sort of brought some of that energy back out of the airstream. We haven't rally looked at it very closely, but we do want to take advantage of it in this NVP process.

BULLEN: Dick Parizek?

PARIZEK: Your discussion about why that blue air return tunnel wasn't above implies the possibility of water or maybe uncertainty with water accumulating in it and where that would end up. That sort of brings back some of the concerns that Dan Bullen had raised about the ECRB crossing roughly 20 percent of emplacement drifts. So, as a kind of a disconnect here, if it wasn't a problem then, is it a problem now or would it be in a way up there anyhow?

MCKENZIE: That's a very good point. There's a key difference though. The exhaust drift has got a direct intentional vertical connection into every emplacement drift that it passes, either under or over. The ECRB doesn't have any. We didn't want to drill any holes for that reason. So, we hope to not connect the cross-drift to any of the emplacement drifts directly.

BULLEN: Any other questions from the Board?

(No response.)

BULLEN: Actually, I have one. If you're looking at thee heat transfer characteristics, the heat transfer from the waste package to the wall is predominately radiation, is that not correct? So, if you emplace the drip shield mailbox sooner and still had air flow above and below it, would it give you greater heat transfer surfaces for the ability to remove heat and then would you not have as much latent heat left in the mountain? I mean, we're assuming about 50 percent heat removal here or maybe two-thirds heat removal, but you've still got a lot of heat that's stuck in the mountain after that 50 years of ventilation. Could you lower that amount of heat that's there by putting in drip shields as essentially radiators?

MCKENZIE: What do you think, Jim?

BULLEN: Just a question as I think out loud because those are the kinds of--I know you have a $4 billion cost deferral and all those other present value works that jump up and bite you, but if you wanted to take a look at optimum heat removal and it's radiation, just don't radiate to the rock and then the rock doesn't get hot.

MCKENZIE: Well, it has to radiate to the rock anyway, right--

BULLEN: It has to do it twice. It's got to go to inside of the drip shield and then it's got to radiate out again and I've got an opportunity to do the heat transfer and get it out, right? Don't I have a load convection there?

MCKENZIE: You might get a little more convective heat transfer directly into the air. We don't take much credit for that in the current model. But, again, you know, it's something we could look at. That's something we could model, actually.

BULLEN: Yeah, I was going to say that's easily modelable with the kinds of codes that you're using.

That was my last question. Any other questions from the Board?

(No response.)

BULLEN: Questions from the staff?

(No response.)

BULLEN: Now, I'm amazed because I am now two and a half minutes early and I was going to be very apologetic to my compatriot here. No, my chairman is going to cut me off. Dr. Cohon, do you have a question?

COHON: I just didn't want you to use the two and a half minutes.

BULLEN: I was going to defer to Debra on my own. Dr. Knopman will take over now as the session chair on drift scale testing. Debra?

KNOPMAN: Thank you, Dan. We can use these two minutes.

Our next presentation on the drift scale heating test by Deborah Barr of the Bureau of Reclamation is a very important bridge between today's session on repository design and tomorrow's update on the science program. The Board is very interested in the connection between the LADS assumptions on thermal effects, particularly on water movement, and the results that are coming from the drift scale tests. I know Deborah's presentation is going to get into some of these questions; what do we actually get out of this test that's applicable to EDA II or whatever design happens to be chosen and she'll also, I hope, get to the question of how well, how applicable these conclusions and results are coming out of this test to the lower lithophysal unit even though the test itself is located in the middle non-lith.

So, Deborah, take it away?

BARR: All right. Someone pointed out to me earlier that we're writing our own thermal test right here in the building as we speak here. It's a lot cooler up in front here and I can almost say I'm glad to be here.

Okay. Just to give you a little bit of warning, I put far too many plots into my talk here and so I'm going to skip through a few of them. However, they are available there in your packets so that you can look over them at your convenience, and if you have any questions about them later, then by all means, I'll be around to discuss it.

What I'm going to talk about in this presentation first is an overview of the thermal testing program with an emphasis on the drift scale test. Then, I'm going to give a brief status of the drift-scale test and go briefly over the results that we have to date, so far. Then, I'll talk a bit about the integration of the three thermal tests that we've performed in the program or are performing, so far. Then, I'll go on to discuss the applicability of the drift scale test results that we have, so far, to areas such as other designs or other rock types.

Now, the thermal testing program on the Yucca Mountain Project, so far, covers three tests. Two of them are already essentially complete and one of them is still in progress. The single heater test is now completed and the final report is currently being reviewed by DOE. The second test, the large block test, is essentially complete also; however, the results will be incorporated into a future report. The third one, the drift scale test and the largest of the tests, is currently in progress.

The objective of the drift scale test which we had stated before the test began and what our goal was was to develop more in-depth understanding of coupled thermal, mechanical, hydrological, and chemical processes anticipated in the local rock mass surrounding the potential repository.

Just as a brief reminder, here's a diagram of Alcove 5 layout. We have the main drift down here. We have the turn off into Alcove 5. Here's the observation drift and then the connecting drift. Then, you turn into the heater drift itself. Over here in blue is the location of the single heater test, the one for which we are now reviewing the final report. Then, in this red region here is the drift scale test.

This is another diagram to show you the layout of the tests, as well as the layout of the instrumentation. Again, we have the observation drift here, the connecting drift here, the heater drift here. The bulkhead is right about in here. And, all of these colored lines here represent the different testing boreholes. The red represents the wing heaters and then all of the others represent various thermal, mechanical, hydrological, and chemical testing boreholes. The ones that extend off of the heater drift itself, they were instrumented before the beginning of the test and they're permanently instrumented since we now no longer access them. In the observation drift, we have these boreholes through which periodic measurements are carried out, as well as some permanent instrumentation in those, as well.

Now, the current status of the drift scale tests, we currently have completed 19 months of the heating phase. There's four years of heating planned followed by a four year cooldown period. Currently, the drift wall temperatures are approximately 175 degrees and our goal is to reach 200 degrees for the drift wall temperatures. We're anticipating reaching that pretty soon. So, we're beginning to evaluate the process of ramping down on the heating so that we'll approach that 200 degree goal in a smooth fashion. Now, the 100 degree isotherm is now approximately two meters into the rock mass around the heater drift and about six meters in the rock mass above and below the horizontal planes of the wing heaters.

Now, this shows some of the thermal results here. On the X axis, this is distance from the center line of the heater drift. Let me show you a diagram here to orient here. This is essentially from two boreholes that are in the plane of the wing heaters themselves and they're extending out from the heater drift. So, there's one that's going off this way and one that's going off that way if I haven't completely blocked your view. These are from Boreholes 160 and 164 and the Y axis is temperature. This is a time progression in 25 day increments of the thermal profile from these boreholes. I have an animation here that's going to show it a little bit better. Let's go on to the next one.

Okay. Before we start, let me show you again, we have the same axis here. Again, the center here represents the center of the heater drift where the canisters are and here we have temperature on this side here. Now, this is incremented here and we're going to go ahead and start. It goes on up, and then right about here, this is at about 96 degrees and that's the boiling front. So, this is where the boiling front has passed through these particular thermal sensors within these boreholes and we have that heat piping effect which goes on. It kind of stays there for a little bit and then we go on and you see those characteristic profile from the wing heaters again and it continues on through time. I think this is up through Day 525 or something at the maximum. These are boreholes 160 and 164. They're about midway down the heater drift. So, they're within the region that is not covered by the concrete liner.

Let's go ahead and run through this again since Dan McKenzie has freed up some time for me. Again, we'll start here and you'll see it increasing here and then we level off here at the boiling front and then we continue on.

PARIZEK: The little chinks in the top, why little chinks, the wrinkles on the top?

BARR: This is the outer wing heater and this is the inner wing heater and then this is the inner wing heater on the other side and the outer on the other side.

KNOPMAN: Deborah, if you would just--there, close to the center line, you have--it's low and it's not obvious why it's so low. It's relatively lower right at the center line.

BARR: Right here?

KNOPMAN: Yeah?

BARR: Well, this is--so, you're asking why?

KNOPMAN: Yeah?

BARR: This is because the heaters in the drift itself are running at a lower output than are the wing heaters. We started those off at a higher rate than the heaters in the drift itself.

Skip this one. Okay. This is another simulation here and let me explain it a little bit before we give it a go here. The lower one, what you're going to see is contours. This is the heater drift itself. Imagine it in the same orientation as the previous plot we looked at. The wing heaters are going off this way. The bottom here is actual measured temperatures and the top here is predicted temperatures using the dual permeability model. So, let's go ahead and start this one. So, you see the higher temperatures are here at the outer wing heaters. The inner wing heater is this little spot right there.

So, there are some differences between the predicted versus the measured; however, they're not vastly different. And, in fact, temperature is probably the easiest thing to model and one we have the best grasp on, so far, as far as modeling processes. Let's go on to the next one.

Okay. Now, let's take a look at some of the mechanical measurements. This plot shows some of the MPBX measurements; that's multiple point borehole extensometer. Here's an orientation plot right here to look at. It kind of needs an up arrow. Basically, you're standing on the side looking at the drift. It's as if you're standing--well, actually, you'd be over on this side, I guess, looking at the heater drift. Okay. Here's the bulkhead, here's the heated portion, and then these are the two boreholes that we're looking at the measurements for. These MPBX boreholes, they have anchors at one meter, two meter, four meters, and 15 meter depths into the boreholes. The data that we're looking at here are from these two particular boreholes and it's from the collar to the third anchor which is the four meter long segment of this particular borehole or these two particular boreholes. So, what we're seeing here on the plot is in the solid line with the diamonds on it is the predicted values that we anticipated. The other lines are the actual measurements. Now, I know this looks pretty scary, but in actuality, these trends are probably about some of the clearest that we've got. The reason for this is because the mechanical instrumentation in the drift scale test tends to not react as well to temperature. So, proportionally speaking, with the mechanical instrumentation, we have a larger loss rate than in a lot of the other instruments. And so, this is why you're getting a lot of this variation here, but you know, this is actually some of the clearer trends that you can see from the instruments that we have.

Okay. Now, let's look at the air permeability of the testing in the program here. Across the X axis, we have the dates. So, you've got a time sequence here. And, on the

Y axis, you have the ratio of measured air permeability to preheating permeability. So, the first one was taken at ambient conditions and therefore, it's a 1.0. Then, over time, you see a decrease in the air permeability and the reason for this decrease in permeability, it's due to the saturation accumulating in the fractures as it's driven off by the heat. So, this is a temporary scenario here. As long as the vapor and the water is being driven off, it's filling these fractures. It's reducing the air permeability. And, once this heating phase has passed and it returns to normal conditions, then this decrease in air permeability will disappear. As a matter of fact, in the single heater test, we found that post-test air permeabilities were actually slightly greater than pre-test air permeabilities.

NELSON: Deborah, could I ask a question? Can you explain what are the different lines, 74, 76, 78? What are these referring to?

BARR: Okay. Well, the first number, 74, 76, and 78 are the borehole numbers and then the second number after the dash is the packed off interval. In each of the boreholes, there are packers at certain intervals which divide it up into four segments. And so, the first segment, I believe, is the one nearest the observation drift and then it goes 2, 3, 4 from there.

Okay. Now, let's take a look at some of the geophysical measurements. This is the electrical resistivity tomography. And, resistivity in the rock is dependent upon the water content and the temperature. So, in this case since we have a grasp of the temperature, we can then calculate what the water content is and we can convert this resistivity to saturation. First off, let me tell you about the saturation ratio so you know what the colors mean. In ambient conditions, the saturation ratio is .9 to .92 and that's 90 to 92 percent saturated. So, your ambient conditions are going to be right about in here with this color. Now, as you move to higher saturation ratios, that's a higher saturation. So, you're accumulating saturation there. If you move to lower saturation ratios down through the greens, yellows, and oranges, that's showing a drying. Okay? So, you have decreased saturation there.

Now, on this upper plot here--

KNOPMAN: Excuse me, Deborah. Could you explain what one point--how you get a 1.2 saturation ratio, what the physical meaning of that is?

BARR: You know, that's a really good question. I think I'd have to defer that. Maybe if we could--

DATTA: That ratio is the ratio of the saturation at any time during this test with the baseline one that was measured before the test.

BARR: Okay. All right. So, that would suggest that ambient is 1.0 rather than .9--

DATTA: Exactly. Exactly.

BARR: Okay. So, I have this information--

KNOPMAN: Could you, please, identify yourself just for the record here?

DATTA: Robin Datta, M&O.

KNOPMAN: Okay, thank you.

BARR: Okay. On this upper plot here, up is to the top of the plot and down is to the bottom. Over on this diagram on the side here, what you're looking at is this plane right here cutting right down through the middle of the heated drift and you're looking at a cross-section which extends the entire length of the heated drift. So, on this upper one, you can see that there's this drying out zone just to the top of the drift and below it, you know, by the greens and the oranges and yellows and such. You can see in the measurements here that there is no real increase in saturation above it. However, in the area below, we do see areas of increased saturation. So, this is demonstrating, as we've seen in the single heater tests and the large block tests, that you don't have areas of increased saturation which perch above the heat source itself, that they tend to move down below.

Now, on these bottom two diagrams, here's the heated drift. It's as if you're standing at the bulkhead looking through the little window and down through the drift itself. The observation drift is over on the side here. Here's the wing heater. And, you can see the drying zone around the wing heater here and the areas of increased saturation are up here and down below. This one over on this side, the left side, is the one nearer to the bulkhead. It's relatively close to the bulkhead. Probably right about in here, but it doesn't correspond exactly with that line right there. The one on the right is more midway through the drift. It's probably right about here. Again, though, it does not correspond with that particular line, but it's close to it. And, again, you see the drying zone around the wing heaters and you see the increased saturation over here. Both of these, you're not really seeing any kind of increase in saturation above the drift itself, although the data doesn't extend farther over.

Now, in this plot, what we're showing here is the difference between the dual permeability model versus the equivalent continuum model. This is simulating the saturation after one year of heating. So, on the left here with the dual permeability model, in the DKM model, the coupling between the matrix and the fracture permeabilities is weaker than it is in the ECM model. This allows for more flow through fractures. Because of this, you're seeing the increased saturation zones tend to be more below the test itself. Whereas, over in the ECM, you have more of a halo of increased saturation. Now, in the equivalent continuum model, the ECM model, it's like a closed system and it doesn't really allow the saturation to leave the system.

Okay. I'm going to show another animation here. This one is going to show some of our neutron logging data. So, let me kind of explain what you're going to see here first. Again, same orientation; you're looking down the drift here. You've got the wing heaters in red here. The observation drift is over on the side here. What we're going to see is a yellow line up here which represents the 100 degree isotherm. It's going to start out at the wing heaters and it's going to grow and you're going to see the progression of that 100 degree isotherm as it grows over time. Now, the neutron logging data that we're going to show is along this borehole right here. I believe it's going to be a purple line. Where you see that line deviating from the borehole line itself is where you see evidence of drying. So, the deviation from the line indicates the drying. So, let's go ahead and start it.

Okay. There's the neutron logging data. We've got our 100 degree isotherm. Stop here. And, you can see that we've got the deviation in the neutron logging data indicating drying in the region of where the 100 degree isotherm is around here. Now, keep in mind, though, that these blue lines are the boreholes wit h the thermal couples in them and that's where we actually have temperature data. So, anything in between those lines is estimated as far as the 100 degree isotherm is concerned. And, yet, we have very good control over the points on the blue lines themselves because that's where our thermal couples are located. So, let's continue on. So, you see the drying zone increasing as the 100 degree isotherm moves outward. And, let's just run through that one more time. Okay. There's our 100 degree isotherm.

Okay. Now, let's go on to talk about the role of CO_2 in the test. Now, actually, I'm not sure I have enough time to really go into the details of what's on this plot, but what I'd like to do is start off by just sort of giving you the scenario of what we're learning from this. Essentially, that's when you heat the rock mass at sub-boiling temperatures, the CO_2 in the pore water is exiled out and it's driven off by that heating front at sub-boiling temperatures. So, closest to the heaters, you have an area of low CO_2, partial pressure CO_2, and then as you move out from there, you have a halo around the test. You have a halo of increased--well, it would be more oval here because of the wing heaters. You would have a halo of increased CO_2, and then beyond that, you would have ambient conditions CO_2. So, the reason why this is important is because as you dry that

CO_2 off in the halo and you have that higher concentration of CO_2, it's followed by the boiling front or the 96 degree, you know, boiling front which then vaporizes the pore water, drives it off as a vapor, and that vapor then moves out into the cooler rock mass where it then condenses. Now, if it condenses while it's in that higher concentration CO_2 front, then it interacts with that CO_2 and it precipitates into water that has pHs in the range of 4 to 5. Then, that water will react almost immediately with the calcite that's in the fractures and things like that which will then buffer the pH of that water and it will raise it then to a range of about 6 to 7.

So, what we observed is most of the water samples that we've collected have been in the pH of 6 to 7 range, and yet recently we collected some samples which were in the 4 to 5 range and what we eventually determined was that what we were actually doing was wee were drawing out the vapor which was then condensing in the line that was collecting the sample and it never had the opportunity to interact with the calcite in the fractures which would buffer the pH.

So, on this plot right here, what you're seeing is on the X axis is the partial pressure of CO_2 and on the Y axis, what this is it's just saying whether your borehole is extending upward or downward. All right? Everything above the zero is the boreholes that extend upward; everything below are from the boreholes that extend downward. And, most of our data is from the boreholes that extend upward because in the ones that are downward, if there's water in the packed off intervals, then it's not possible to collect the gas samples. So, you see that nearest the heater region or the level of the wing heaters, you have low partial pressure of CO_2, and then as you move away from it, you have this high concentration halo of CO_2 and then it drops off again towards ambient. The red line here represents the simulated data and the blue dots represent the actual measured points.

Okay. So, what have we learned or what are some of the key observations from the thermal testing program? We've seen that moisture which is driven off by the heating moves below the heated region through fractures and doesn't perch above the heated drift, as we had thought before we started the thermal tests on the program, and we've seen that beyond the dryout zone the air permeability decreases due to mobilized water filling the fractures. Also, we're improving our understanding of the thermal-mechanical rock mass properties. Now, all three of these points are important in our understanding of the near-field environment, as well as the behavior of the unsaturated zone.

I've got four more things here. We've also seen that when it comes to simulating the movement of moisture, the dual permeability model does better than the equivalent continuum model. However, when you were trying to simulate thermal behavior, the DKM and the ECM model behave pretty similarly. Then, as far as accommodating simulation of the thermal, hydrologic, and chemical behavior, the dual permeability model does better than the equivalent continuum model. This is because the chemical behavior is very much tied to the hydrologic behavior. Since the dual permeability model does better with the hydrologic aspect, it also tends to do better with the chemical, as well. And, as you saw in the CO_2 plot that I showed, CO_2 exsolves from the pore water and is driven off in a high concentration halo, and then as vapor condenses within that halo of high CO_2 concentration, the CO_2 interacts with the water and results in water samples with a lower pH. However, they're then almost immediately buffered by the calcite in the fracture network.

So, all of these points here on this page are very important when you're considering again the near-field environment and the behavior of the unsaturated zone. And, they're also very important for engineered barrier systems and waste package, things like that, because how the hydrologic behavior occurs in the program is very important as far as how it may impact those particular aspects.

Okay. Let's look at the three thermal tests and how we've been able to improve our testing over time based upon what we've learned along the way. Our experiences in the single heater test helped us to add and refine measuring systems in the drift scale test. One example of this was the addition of the hydrology holes when we found that we could collect water samples in the single heater test. We had been unaware that we would have that volume of water and that we could actually collect it in the single heater test. So, when we found that we did, we added these hydrology holes to the drift scale test and now regularly collect water samples where available. The water analysis in the single heater test revealed that CO_2 was a factor and so gas sampling was added to the drift scale test. And, again, we found that the moisture did not perch above the heat source and this was demonstrated in the large block test and the single heater test and we're seeing it again in the drift scale test.

All right. As we consider design options such as you heard about for most of today, it's important to re-evaluate all the areas of testing on the project and determine if the results of these tests are applicable to the conditions that we may observe in any alternative design scenarios. So, in light of the drift scale test goal to understand the thermally-driven coupled processes, the understanding of these processes can be applied to a range of different design configurations or heating scenarios. The range of behavior that we're striving to understand in the drift scale test encompasses the behavior anticipated in most of the repository designs, and thus, the drift scale test that we anticipate gaining and the duration of the drift scale tests, if they go through to maturity, can be used to evaluate conditions in other design scenarios. The results can also be applied to modifications of designs which may occur in the future as we refine our understanding of what factors are significant.

Another important area to consider is what can we say about how the behavior of the lower lithophysal will differ from the middle non-lithophysal. The bulk of the proposed repository is now designed to be within the lower lithophysal, and therefore, it's important to understand the behavior of it. Rock properties which vary from unit to unit and even sometimes within the same unit are properties such as thermal conductivity, thermal expansion, permeability, porosity, saturation, and mineralogy. By designing and implementing a large scale test such as the drift scale test, we're working to build a broad foundation for understanding how coupled processes are influenced by these rock properties.

So, what we're planning on doing here is we'll use the process models that we're developing in the drift scale test and we'll make predictions using estimated properties for the lower lithophysal. Then, we'll go on to validate the process models by testing those predictions and refining our process models with the information that's derived from the planned ECRB thermal test. And so, an objective of the thermal test program is to develop robust process models that can be used with greater confidence in a variety of conditions and a full range of thermal load.

So, I guess, in summary, the issue of applying what we've learned to the lower lithophysal, can we use the process models that we are developing to model what will happen in the lower lithophysal? Yes, we can, but there's a certain amount of uncertainty involved until we have the opportunity, unless we--or if we have the opportunity to test it against the lower lithophysal, then we'll be able to develop greater confidence in those models. However, by understanding the processes which occur, we've built the foundation to be able to do that.

So, if I haven't stunned you with the speed that I went through all that, then is there any questions?

KNOPMAN: Thank you, Deborah. Let me just say that we would like to honor, as best we can, the 5:00 o'clock time for the public comment. However, we did interrupt Deborah a couple of times for clarifying questions. Let me just ascertain how many questions we have from the Board? Okay. We'll just try to keep the questions and answers to the questions concise.

Albert?

SAGÜÉS: Yes. It looks like one of the most striking findings is the observation of thermally-driven moisture below the heated region. Now, does all the evidence for that basically come from the electrical resistivity tomography?

BARR: No, no. We're seeing that in--well, for instance, we have yet to collect any water samples from the boreholes that trend upwards. We're seeing that in the geophysical measurements. We're seeing that in the neutron logging measurements. There's no drying out zones around the neutral logging holes that we periodically collect data from. I'd say that it's being verified in all of the testing aspects that we're able to at this point.

SAGÜÉS: And, your electrical resistivity tomography has to assume a certain conductivity for the pore water, I presume?

BARR: I'm sorry, I didn't quite

SAGÜÉS: The electrical resistivity tomography models that you use have to assume some electrical resistivity for the pore water, presumably. Now, do you know if those are correct for temperature? I mean, for temperature, maybe you can do it, but can you correct that for composition?

BARR: I believe--and Robin, correct me if I'm wrong--but I believe that there is currently no correction being done for composition variations in the water. Is that right? Okay.

KNOPMAN: Dick?

PARIZEK: You showed us in Figure 15, the purple, toward the bottom of the heater experiment area, there was increased moisture under the experimental site. Then, on Figure 17, then you gave us animation following Figure 17 and you showed that 100 degree boiling front. But, we never did see moisture building up anywhere along that incline, Monitoring Point 67, I guess. It was always sort of hanging the same the whole way through. So, how did the water get down there because you started with Day 1 on the animation, whereas this other one is at Day 461. So, we might have missed when the water ran around and got down there. We want to see how it gets down there. Does it go around on the outside of the heater? You're saying it gets there. We just want to know how it gets there?

BARR: Well, we believe that it's actually gravity-driven through fractures.

PARIZEK: But, none of these holes hit that except the little blip that was on that Borehole 67 showed something sticking up.

BARR: So, you're saying in the animation, we're not showing areas of increased saturation?

PARIZEK: Not in this one. We never did see water building up anywhere. It just dried out.

BARR: Well, in this case, the deviation from the line indicates drying. I don't believe that--

PARIZEK: So, it could be just around the edge of it somewhere nearby that that hole didn't show us. But, you don't show it in 69 down below or you haven't seen it any other hole?

BARR: An increase in saturation?

PARIZEK: Right?

BARR: Actually, you know, I am unaware if neutron logging actually really gives you clear indication of increased saturation. Maybe, is there someone else that could possibly answer?

PARIZEK: It should get you up to 100 percent. I mean, if it's less than 100 percent, it ought to--

BARR: It's pretty close to 100 percent already if it's in the ambient.

PARIZEK: Excuse me, again. That little kink that's up on the upper left, is that wetter than 100 percent?

BARR: Robin, can you address that?

DATTA: Neutron logging actually measures the water content of the rock at the--of the hole. The measurement is not very deep into the rock. This is so you just--the drying in one particular hole, around one particular hole. Neutron logging doesn't measure the increase in saturation very well because our starting saturation is over 90 percent. So, increased saturation--is not that good. We cannot track increased saturation by neutron logging very well, basically.

PARIZEK: Okay. So, the resistivity experiments might show that if we look carefully?

DATTA: Yeah. Resistivity by the ERT that you saw and also the GPR, both are showing increased saturation below the heated region. Both those measurements are showing that.

KNOPMAN: Okay, thank you. Priscilla Nelson?

NELSON: This may be pretty silly. I'm looking towards the rock mass above the opening draining somehow by gravity, freely, through fractures. The water that's accumulating below is not draining. I mean, I would expect it to drain, too, would you not, vertically down and out? Why is it sitting there waiting to be found? Is that silly?

BARR: No, actually, that sounds--go ahead, Robin?

DATTA: That picture is actually showing matrix saturation, not fracture saturation. The two pictures that you're seeing--

NELSON: Well, now, you've got me really lost.

KNOPMAN: Could you clarify what your response--briefly?

DATTA: The pictures.

KNOPMAN: Can you go back?

BARR: 15, #15? Yeah.

DATTA: And, Priscilla, what is your question?

BARR: She's asking--you're saying it's matrix saturation and not fracture saturation.

DATTA: That's correct.

BARR: She's asking for clarification.

KNOPMAN: The question is why is the water below the drift not draining also? Why is that showing up as a result there. It looks like it's pooling, ponding.

DATTA: It's not pooling. It's just difference in saturation. The issue of the saturation, that, we measured before we started--you know, at the time of the measurement, basically.

BARR: The matrix saturation at ambient is about 90 percent already. And so, if we were showing fracture saturation, then you probably would not see any kind of increase below because it continues to move through the fracture network. But, the matrix saturation itself can increase to some extent.

DATTA: Yeah, the moisture is getting imbibed into the matrix of the rock and what we are seeing is a--of the saturation before and after.

KNOPMAN: Okay, thank you. We have two--any questions from the Board staff? Leon, last question?

REITER: Just a point of interest. Using in many ways geophysical inverse techniques like resistivity and ground radar--you didn't show the radar--but both those techniques have very large uncertainties associated with resolving away from the measuring point. I think you have to show those uncertainties--not only show what your best predictive solution is, but what the uncertainties are so you avoid the problem of what's really happening slipping through the uncertainty window.

BARR: That's a very good point and I didn't mention that when I talked about this slide. The lines with the kind of dots along them represent the areas where the actual measurements were taken and the accuracy is greatest near those lines. As you move away from them, you're decreasing your accuracy of your measurements.

KNOPMAN: Okay. Thank you very much, Deborah. I'm sure we all have more questions which we'll get to you afterward. But, I'll turn the gavel back to our chairman.

COHON: Thank you, Debra, and thank you, Dan, both of you for your wonderful job of chairing. Our thanks to all the speakers today for their fine presentations and their willingness to engage with the Board in dialogue and in answering our questions.

We have three people that have signed up to make comments; Sally Devlin, Judy Treichel, and Abby Johnson. Did we miss anybody?

(No response.)

COHON: Okay. We'll do it in that order. Ms. Devlin, we're going to try to keep this to again about eight minutes by my watch.

DEVLIN: I do owe an apology to Abby because I said there were 300 people in Eureka and I'm always wrong. It's 1800 people in Eureka County that have the privilege of virtually everything.

I do want to add something because I didn't have the time before and that is finally Pahrump is getting a community college and I just went into Henderson to see that new facility and it's breathtaking. We do intend to get a chemistry lab, physics lab, biology lab, and so on, as well as the arts, and adapt it. My concern is because Lake Barrett said it will be two years. That is not acceptable. We go to work tomorrow. The reason is we've got to educate our kids. We have NTS Development Corporation which I hope succeeds and brings in private industry. We're going to have 60,000 people and we've got have jobs and we've got to have them educated and we've got to have them treated properly medically all over Nye County. So that we do start tomorrow and I'm going to ask everybody's help.

The other question that I have is we asked at the January 27 meeting for all kinds of information. The Nelson limits, the report on the rock testing outside of Yucca Mountain from Livermore, the Pioneer 10, and many other things and we gave a long list. I also called Washington. We have never received anything. And, as the public--and I'm not the one asking for these things. I just disseminate the information that people can read them. I certainly can't. But, then, they teach me the principles of them. So, I'm again asking you, Jared, to get people on the street because this is what you're supposed to do and it's not nice when you don't get these things to your grandmother.

The other thing is again welcome and I have one question. I hear all this stuff on the hydrology and the matrix and so on. And, they're doing the heat testing at 100 degrees, but the canisters are 360 degrees C. I don't quite understand how valid 100 C is as compared to 360 C. And, maybe at the questions and answers you can say this. I see this science and it just doesn't make common sense. So, we need some help. And, thank you again.

COHON: Thank you, Ms. Devlin. Would someone like to take on the questions she posed? How is it that you could have a waste package at 360 degrees and rocks that are only 100? While you're getting ready, let me just say, Ms. Devlin, the Board endeavors to meet all requests for information. We're not perfect, though we think we do a good job. We will redouble our efforts, however, to make sure you get everything that we produce and anything else we can help you with.

Ernie is going to answer the question. Here it comes, Sally. Oh, Jim, sorry.

BLINK: The peak waste package temperature for EDA II was around 240, not 360 C. 350 was the limit for the cladding temperature that we did not want to exceed and we did not. 100 degrees C or actually 96 is the highest temperature that liquid water can exist without salts at this elevation. At temperatures substantially above that, you don't have corrosion even if the waste package is higher because you need the water to have the corrosion. We do some tests at elevated pressures to look at corrosion at higher temperatures as accelerated measures.

COHON: Excuse me. No, that wasn't the question. This is a much more basic question. Given that you've got a piece of metal, the temperature of which is, say, 250 degrees C, how is it that the rock not that far away is only 100 degrees C? What's the physics of that? How does that happen?

BLINK: When there's no backfill, the temperature of the rock and the metal are much closer together; 1 degree to 10 degrees, perhaps. When you have the backfill in between, it's like an insulated blanket and there's a large temperature difference across the backfill that accounts for it.

COHON: So, in fact, Ms. Devlin, if one would just start out as they did in the so-called EDA I, that one alternative, to design a repository where the rocks would never be hotter than 100 degrees C, it's not just a matter of sticking in this very hot waste. You have to do other things like backfill and also spread them apart so that the heat is dissipated.

DEVLIN: (Inaudible).

COHON: Repeat the question?

DEVLIN: (Inaudible).

BLINK: She asked if there is microbial testing and the answer is yes. I'm happy to talk to Ms. Devlin off line. I'll be here tomorrow, as well.

COHON: Okay. Thank you.

Judy Treichel?

TREICHEL: I just need a clarification and I came up here so other people can use the other microphone because I worry about the schedules for the summer and public comment because people want to be able to participate. We've just had the big rush on the NRC rule and we're coming to the other one. Jim Blink made a comment and I didn't catch it all, but it was something about when there was a discussion over whether or not the design would be finalized if there would be an absolute design at the time that the draft EIS came out. The answer was no. And, Jim, didn't you say that sometime in the year 2000 that there would be an EIS adjustment or an EIS something to address the design?

BLINK: I probably should punt this to one of the DOE people, but I believe I've heard there's going to be one more EIS calculation; that is a calculation with the EIS rules.

BARRETT: The DEIS that will be coming out for the summer is based on the technology and the engineering models in place for the viability assessment. It does not have the next step design enhancement that we've been basically talking about today, the EDA II. What the EIS does under the NEPA rules and the CQ guidelines bounds things. So, knowing there was going to be evolutions in the design, we've known it for years and it's going to continue on, bounds it by looking at three different thermal loads. I think, it was a 25 low, something in the middle, and 85 which was the high which was the VA because we did not believe we'd ever go hotter than the VA design. That will be in the DEIS when that is published. We expect comments that would come when we put the DEIS out that says, gee, you've now evolved the design to something--you know, the lower thermal load, the EDA II, you know, whatever the refined design is. Would you, please, tell me specifically how that fits into that range? So, we are planning from the engineering/science point of view to do some analyses that would feed that for the final EIS which would basically just be refined to show that we will be in the scope of what we have in the three thermal loads in the DEIS to be ready with the FEIS. That would be the enhancement, the refinement that Jim was just referring to. That would be, you know, basically in the year 2000. It should be basically the same thing that would be in the site recommendation consideration report that may be in November of 2000.

TREICHEL: Okay. I think that's unfair because you're giving people three things to choose from, none of which exist. You're here discussing what you actually plan to use maintaining flexibility, of course. So, that could also change. But, this is the same business we've always had where we get a chance to comment, drive ourselves crazy to make deadlines which, you know, other people slip, but we have to make, and do a heck of a lot of work for almost no pay or certainly in the case of the people out there, no pay at all. It's not what's being talked about and you retrofit later. And, you have absolutely refused to extend the comment period. Ninety days is enough for, you know, one of the most important projects in this country and this is the kind of thing that gets lost in the mix.

I think, it's not fair. I think it's very unfair. And, certainly, you can't expect people like the head of Citizen Alert, myself, just a handful of grass roots people who are getting all of these calls about these comment periods to say, oh, no, this is what you'll see in there, but actually there is EDA II and let me tell you that--you know, we're not in a position to do that. I think, it's being dishonest by throwing it out there and then sort of retrofitting probably after the 90 days and there people are.

They have not commented on--you, yourselves, certainly know what's in the thing today.

So, I think these short deadlines, this is just a symptom of what happens. It's happening on the EIS. It's certainly going to happen on the site recommendation consideration report. And, I want it on the record somewhere.

As long as you're there, I'll take two more minutes. I think it's really--

BARRETT: We can do it off line and not hold everybody up.

TREICHEL: No, I think it's interesting that you've now go the solar powered repository. This is incredible because people from the project office now when we go out to do public information forums together have suddenly entered into the realm of nuclear power. We were never allowed to talk about that. But, they will quickly say that solar power cannot be a replacement because it's too costly, it's too ineffective, and it's too unreliable. Now, I think it's incredible that that's been your choice for the 200 year survival package for the high-level nuclear waste repository.

That's it.

BARRETT: I don't think we in the program have ever said those things. I mean, solar power is part of the Secretary's initiative. Wind power renewables, that's an important part of this administration.

TREICHEL: --shot down like big goose every time.

COHON: Thank you. Abby Johnson from Eureka County?

JOHNSON: Hi. My name is Abby Johnson and I represent Eureka County, Nevada. I have two comments. I, too, am taking advantage of Lake Barrett being here. I have two comments directed to DOE and one comment for the Board. It's going to sound a little bit like Judy, but we didn't talk beforehand about this.

I want you to know hat all 10 affected units of local government and the State of Nevada agree on something and that is that we need 180 days to review the EIS. We've all written letters to Lake Barrett. He said, no, we need to keep it at 90 days because of the schedule. In Russ Dyer's presentation, there is a milestone chart here. It looks to me like there's an extra three months here. If instead of the final EIS being completed in the summer of 2000, if it were completed in the fall of 2000, that would be the three months that we need. DOE doesn't need the final EIS until the site recommendation. That is, unfortunately, in November when we get to comment on that.

So, I guess, you want to talk? That's my first comment or question.

BARRETT: The schedule for the FEIS is August of 2000. Long-standing schedules always have been long-standing schedules basically for the last 10 years except the LA because of '96 budget which slipped a few months. We've basically held it for the last 10 years on the program. The Government is in multi-billion dollars worth of litigation. I think the Federal commitment to deal with this is an important part of it.

Now, there's no impact on me to do them all together in November, although there is an impact and it's the people and the budgets. I would have to do the site recommendation and the FEIS simultaneously and I would rather do those in sequence as far as the person loading to get them out. So, there is an impact why it's important that I keep them sequenced. And, also, we wanted to get the environmental impact information out to people ahead of time because if I put them all out together, then there would be the accusation you're dumping all the information at the same time and overloading the people. So, we're trying to get it out in an open, transparent way as soon as we can. All our science, we try to get out on our internet for everyone as soon as we do it within the extent that we can if the lawyers allow that.

JOHNSON: Well, the difference is that we actually get to comment on the draft EIS. The final EIS is the final. So, my point is that we need more time to comment on the draft EIS and you can add the three months on the end to finalize the final which the public does not have a say in, basically. I know we disagree. We aren't going to do the back and forth thing.

But, one clarification and that is that at the time of scoping, the Department of Energy did say they were going to have a six month comment period and they have changed their mind. So, just to clarify that, some things have been going on for 10 years and some things just changed and that's something that changed.

BARRETT: And, that changed because we had to stop for over a year on the EIS because of the budget in '96.

JOHNSON: And then, my second comment does concern the site recommendation report review. I do a lot of sort of public information/public involvement stuff. For years, we've always talked about the holiday surprise the Federal agencies spring. And, whatever your reasons for doing this, it appears to be the holiday surprise to make sure that the public is least involved and least interested because it is the time when families get together and celebrate the holidays. So, I think you're doing yourselves a disservice to have that be the comment period.

BARRETT: Heard your message.

JOHNSON: Thank you. My final comment is for the Board. I think you're doing a great job. I think you ask really good questions, really incisive, tough questions. Just in a very nice way, I'd like to encourage that some of that incisiveness and spirit, more of that incisiveness and spirit, appear in your reports to Congress.

Thank you.

COHON: Thank you, Ms. Johnson.

Mr. Danko, we talked a lot about ventilation. I think your issues were addressed in the course of the afternoon. Is there any more to discuss there?

DANKO: No, thank you very much.

COHON: Okay, very good.

Any other comments or questions?

(No response.)

COHON: We thank all the public commenters. Recall there will be another period for public comment tomorrow near the end of the meeting at approximately 2:30.

Three quick housekeeping announcements, literally. One is, please, clean up after yourselves. It's the least we can do in exchange for the wonderful hospitality of the people of Beatty and the use of this very nice facility. Please, clean up your cups and papers and all of that.

Number two, let me remind you again about the dinner this evening. It's 7:00 o'clock. We hope that you meet our criteria for attendance. We will not be using explicit value model, however, and we'll let you know if you meet our criteria or not when you show up.

And, please remember, tomorrow morning at 7:00 o'clock, we have an informal coffee and danish period before the meeting.

We stand adjourned until 8:00 o'clock tomorrow morning. Thank you very much.

(Whereupon, the meeting was recessed until 8:00 a.m., Wednesday, June 30, 1999.)