UNITED STATES

NUCLEAR WASTE TECHNICAL REVIEW BOARD

FALL BOARD MEETING

Developing a Repository Safety Strategy
With Special Attention to Model Validation

September 14, 1999

Radisson Plaza Old Town Hotel
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<u>BOARD MEMBERS PRESENT</u>

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

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I N D E X

P R O C E E D I N G S

(9:00 a.m.)

COHON: Good morning. I'm pleased to welcome you to this meeting of the Board. If you'll all take your seats and get your coffee or whatever else you need to make it through this meeting, please do so.

My name is Jared Cohon. I'm the Chairman of the Nuclear Waste Technical Review Board and it's my pleasure to welcome you again to this fall meeting of the Board.

As most of you already know, perhaps all of you know, but just in case there's one person who doesn't, 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 and it charged OCRWM, in part, with developing repositories for the final disposal of the nation's spent nuclear fuel and high-level radioactive wastes from reprocessing. Five years later in 1987, Congress amended that law to focus OCRWM's activities on the characterization of a single candidate for a final disposal site, Yucca Mountain, on the western edge of the Nevada Test Site.

In those same amendments in 1987, Congress created the Nuclear Waste Technical Review Board as an independent federal agency for reviewing the technical validity of OCRWM's program. The Board is required to periodically furnish its findings, as well as it's 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, date, 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's important. And, they must be transparent to the public.

Our Board meets as a full board two to four times a year. We usually meet in Nevada, often in Las Vegas, and at least once a year in one of the communities in Nye County where Yucca Mountain is located. However, because we do send our findings, conclusions, and recommendations to Congress and to the Secretary, we also try to meet here in Washington once a year. It's my pleasure to extend this special welcome to those from around and inside the Beltway who are able to be with us today.

The President of the United States appoints our

Board members from a list of nominees submitted by the National Academy of Sciences as specified in the law in 1987. The Board is by law and design a highly multi-disciplinary group with areas of expertise covering all aspects of nuclear waste management. I want to introduce to you the members of the Board, and in doing so, let me remind you that we all serve on the Board in a part-time capacity. In my case, I am president of Carnegie-Mellon University in Pittsburgh, my day job as it were. My technical expertise is in environmental and water resource system analysis.

John Arendt--John, if you'll raise your hand so people can see you. John is a chemical engineer by training. He's retired from Oak Ridge National Lab, and after doing so, he formed his own company. He specializes in many aspects of the nuclear fuel cycle including standards and transportation. John chairs the Board's Panel on Waste Management Systems.

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. Dan chairs both our Panel on Performance Assessment and our Panel on the Repository.

Norm Christensen is deal 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 is a physicist by training and has special expertise in energy policy issues related to global environmental change.

Debra Knopman. Debra is director of the Center for Innovation and the Environment at the Progressive Policy Institute in Washington. She's a former Deputy Assistant Secretary of the Department of Interior. Previous to that, she was a scientist in the USGS. Her area of expertise is groundwater hydrology, and she chairs the Board's Panel on Site Characterization.

Priscilla Nelson, we're delighted to note, is the newly appointed Director of the Division of Civil and Mechanical Systems in the Directorate of Engineering at the National Science Foundation. She's a former professor at the University of Texas in Austin and is an expert in geotechnical engineering.

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, and he's a 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. I am very pleased to note that Alberto was recently named a Distinguished University Professor at this institution. We congratulate Albert on behalf of the whole Board. Alberto is an expert on materials engineering and corrosion with particular emphasis on concrete and its behavior under extreme conditions.

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 is a pharmacologist and toxicologist with extensive expertise in risk assessment and scientific team management. Jeff chairs our Panel on Environment, Regulations, and Quality Assurance.

That's our Board. I'm delighted that they all could be here today.

Many of you know and have worked with our excellent staff of which we're very proud and for which we're very thankful. They're sprinkled strategically in sartorial splendor there in front of the divider looking their usual keen and incisive selves. I'm delighted they could be here. Bill Barnard--Bill, raise your hand please--is our executive director. Mike Carroll who is not here today because he's covering another activity for the Board is the deputy executive director for the Board.

We will have with us or already have with us two consultants for this meeting. I want to point them out to you. Naomi Oreskes sitting with the staff--do that again, Naomi? Thank you. She's an Associate Professor of History at University of California-San Diego. She has a very interesting background with a PhD in both geology and the history of science from Stanford. She's an NSF Young Investigator. She works on scientific methods; in particular model validation which is why she's with us and she'll be participating tomorrow in the Panel.

Roger Newman is not yet with us. He's a professor at the University of Manchester Institute of Science & Technology in the UK. He'll be flying in later today. He'll be with us all of tomorrow. He also had a time at Brookhaven and he's an expert in corrosion and he'll also be participating in the Panel discussion tomorrow.

That's our staff and our consultants. I want to say a little bit more about where the program is a little bit more about how we'll conduct this meeting.

Since our June meeting in Beatty, Nevada, the Board has issued two letters to OCRWM. The first letter addressed the OCRWM's repository design efforts and pointed out that some critical uncertainties about the performance of the proposed repository could be reduced in the opinion of the Board if a design were chosen that kept temperatures below the boiling point of water. We had other things to say, but that was the key point we made in that letter. The second letter addressed the OCRWM's ongoing technical investigations. Copies of both letters are available on the tables outside or inside? Outside? Outside. If you're interesting in getting copies of those letters, they're on the table outside the meeting room. They're also available from our website if you prefer to access them that way.

This meeting which we start right now is a very important one. All of our meetings seem to be important, but as we approach 2001, they seem to increase in importance and this is no exception. We're going to have a very full two days of presentations and discussion on significant and timely topics. We're very fortunate for Lake Barrett, the Acting Director of OCRWM, to be with us today. You'll be hearing from him shortly. He will be providing his perspective on the program including some thoughts of what is happening on Capitol Hill and on the budgetary prospects for the program. Lake, we're delighted you could be with us again and I'll call on you again in a minute.

In addition, you will be hearing from Ray Clark who represents the Environmental Protection Agency. The EPA, as many of you know, has recently released a proposed environmental standard for Yucca Mountain and we're very pleased that Captain Clark could join us today to describe the EPA's proposal.

Most of the rest of today will focus on OCRWM's evolving repository strategy. The OCRWM issued its first waste isolation and containment strategy slightly more than three years ago. It revised it about a year and a half later. Since that time, as you probably know, the viability assessment has been completed. Insights from that exercise are now being incorporated into a new strategy. Steve Brocoum and Abe Van Luik will talk about the status of the repository strategy and will provide a context for the more detailed talks that will follow them.

Without commenting on its substance, let me note that the Board is pleased that OCRWM has maintained a repository safety strategy as a living document. We see that as very positive; a document that keeps abreast with new information being developed from field and laboratory investigations. The Board believes that the strategy is a critical piece in the OCRWM's efforts to make a safety case that is clear, transparent, and technically rigorous.

Tomorrow the emphasis of the meeting will shift somewhat. After hearing from Jean Younker about the Yucca Mountain Project's plans for testing and analysis prior to site recommendation, we'll be concentrating on the question of model validation which we feel is a very critical subject. Given the central role now being played by quantitative performance assessment, the question of the validity of the models that underlay those calculations is obviously important. We'll be hearing three presentations from the OCRWM in this area. The first will be a general overview of the topic. Then, we will hear about two specific models, one dealing with seepage into the repository drifts an the other dealing with corrosion of the outer layer of the waste package.

Following, those presentations, we will have an organized round table discussion on model validation that I referred to before. The participants in that discussion include some members of our Board, several technical experts from inside the project, and some from outside, independent experts on the subject.

Finally, let me say a few things about the opportunities we're providing for public comment and interaction during the meetings. It's something that's extremely important to the Board. It's something that we've worked on and always tried to perfect our interaction with the public and given the public as many opportunities as possible to participate in our meeting. Even our configuration of tables to give a more interactive feel to it is something that we've paid attention to.

We're planning three public comment periods during the course of the next few days. One at 11:30 today and one at 4:30 today. The third one will be tomorrow at 11:30. Those wishing to comment should sign the Public Comment Register at the check-in table where the two Lindas are stationed. That's Linda Hiatt and Linda Coultry. They'll be glad to help you in signing up and being prepared to comment publicly when the time arises. Let me point out and I'll remind you again later that depending on the number of people signing up, we may have to set a time limit on individual remarks.

As an additional opportunity for questions and continuing something we've tried out successfully at our last two meetings in Nevada, you can submit written questions to either Linda during the meeting. We'll make every effort to ask these questions; that is the chair of the meeting at the time will ask the question during the meeting itself rather than waiting for the public comment period. We'll do that, however, only if time allows. And, as I pointed out already, we have a very tight agenda and it very well may be that time will not allow this. If that's the case--that is there is not adequate time during the meeting itself--we will ask those questions during the public comment period.

In addition to written questions to be asked by us, we always welcome written comments for the record. Those of you who prefer not to make oral comments or ask questions during the meeting may choose this other written route at any time. We especially encourage written comments when they're more extensive than our meeting time allows.

Finally, I need to offer our usual disclaimer so that everybody is clear on the conduct of our meeting and what you're hearing and its significance. Our meetings are spontaneous by design. These are not scripted events even though I'm reading from prepared remarks. These are not scripted events. Those of you who have attended our meetings before know that the members and especially these members of this Board do not hesitate to speak their minds. Let me emphasize that is precisely what they're doing when they're speaking. They're speaking their minds. They are not speaking on behalf of the Board. They're speaking on behalf of themselves. When we are articulating a Board position, we will make that clear in our comments. Otherwise, we're speaking as individuals.

Well, with those opening remarks out of the way, it's now my pleasure to welcome back to the Board Lake Barrett, the Acting Director of OCRWM. Lake?

BARRETT: Thank you, Jared. Good morning, Mr. Chairman and members of the Board. It's a pleasure to be here as always. I actually think there are probably more people to be dealt when we have these meetings in Nevada than there is when we have it in the Washington area.

First of all, I would like to provide my comments for a broad overview of the program. There will be a lot of details that we're going to go through later on with the staff. So, I'll try to be very brief on that.

First, I would like to make an important announcement related to the management of the program. Last month, President Clinton nominated Dr. Ivan Itkin to be the Director of this office. Dr. Itkin has earned his PhD in mathematics at the University of Pittsburgh and has worked as a nuclear scientist for Westinghouse Corporation's Bettis Atomic Power Laboratory in the design of nuclear propulsion systems for the U.S. Navy. For the past 25 years, he has served as a Democratic legislator in the Pennsylvania House of Representatives rising to be the Democratic Whip and he was also the Democratic Party's nominee for Governor in 1998. The Senate is scheduled to hold a hearing for he and two other Interior nominees tomorrow morning and we look forward to welcoming him as soon as he's confirmed with which we hope is very soon.

Some other developments in the program since last time I talked with you. On August 6, we initiated the distribution of the draft Environmental Impact Statement for Yucca Mountain. We believe that was a very major milestone for us. In accordance with our philosophy of an open, transparent program, we have also placed the document on our Internet website along with the references to facilitate broad dissemination of the information to all. The Notice of Availability was published in the Federal Register on August 13 which officially started the 180-day review comment period. The 180-day comment period responds to requests from the State and from the local government units for the additional time for all parties to review and comment on the document. We will hold numerous public hearings between later this month and in January of next year with the public comment period closing in early February of 2000. We expect to publish the FEIS late in 2000 probably commensurate with the site recommendation consideration report that Dr. Brocoum and others are briefing you about in some detail later today and tomorrow.

The draft EIS indicated that the Department's preferred alternative is to proceed with the proposed action to construct, operate, and monitor, and eventually close and seal the geological repository at Yucca Mountain if the site is suitable under law. This analysis of the repository performance under a variety of implementing alternatives indicates that the Yucca Mountain repository would pose little risk to future populations in the vicinity of Yucca Mountain and affirms conclusions of the viability assessment. The EIS also includes analyses of transportation of spent fuel to Yucca Mountain under different operations methods. These analyses add a key technical element to the public debate over the management of spent nuclear fuel and demonstrates that the risk of transporting spent fuel are low. Our analysis of the transportation impacts is consistent with the analysis done by the Nuclear Regulatory Commission to support its rulemaking on reactor life extension, as well as other analyses done by the Department on transportation of fuel in other programs.

The draft EIS also analyzed the consequences of continued storage of spent fuel and high-level radioactive defense waste at current sites by the nuclear power industries and the Department of Energy under what is referred to as a no action alternative. Because it would be highly speculative to attempt to predict future events, we illustrated one set of possibilities by focusing our analysis on the no action alternative on two scenarios; continued storage with effective institutional controls for 10,000 years which is the same period of focus or the primary focus for the repository and continued storage with no effective institutional controls after 100 years. These analyses cannot be viewed as accurate predictions of the future scenarios. We recognize that neither scenario would be likely if there were a decision not to develop a repository at Yucca Mountain. However, they are part of the draft EIS analysis to provide a baseline for comparison to the proposed actions consistent with the Nuclear Waste Policy Act and the National Environmental Policy Act, as well.

On August 18, another significant milestone in the Nation's geological disposal program was achieved when the EPA released its proposed site-specific rule for disposal at Yucca Mountain. The Department is reviewing this proposed rule and will submit comments as part of the rulemaking process. The Department's primary concern is 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. I understand that Ray will be here this afternoon and speak to you more in detail.

The EPA's proposal responds to the 1992 Energy Policy Act's direction to develop a site-specific regulatory framework for Yucca Mountain. The Nuclear Regulatory Commission proposed a site-specific licensing regulation earlier this year to provide the technical requirements and criteria to implement the site-specific standard. Together, these two regulations should provide a logical and complete set of regulatory requirements for evaluating the Yucca Mountain repository focusing on its ability to protect the public health and safety and the environment. Consistent with its regulatory approach, the Department submitted a new site-specific revision to its siting guidelines which was 10 CFR 960 for geologic repositories to the Office of Management and Budget for interagency review also in August. This version responds to public comments that we received in our 1996 proposed revision and is consistent with the updated proposed standards from the EPA and the technical requirements and criteria from the Nuclear Regulatory Commission. This revision uses the latest analytical methods and best science available in order to support a site recommendation decision. After interagency review, we intend to issue these revisions for public comment period later this year.

Now, turning to the program budget. As I noted in June, the Administration submitted a fiscal 2000 budget request of $409 million for the program. The Senate appropriations included $355 million for nuclear waste disposal which is 54 million less than our request. The House appropriations bill provides $281 million which is $128 million less than our request. We expect that the differences will be resolved by conference committee within the next few weeks.

In light the funding is likely to be less than that requested, the Department is currently reevaluating activities taking into account the advances in the reference repository and waste package designs. We are prioritizing the activities most important for developing information needed to support a secretarial decision on whether or not to recommend the site to the President. We will emphasize the science and engineering activities that most effectively reduce the level of uncertainty in the performance of the repository. Building on the momentum achieved in the last four years, our objective remains to develop the documentation to determine if Yucca Mountain is suitable to support a Secretarial decision in 2001, and if the site is recommended, a license application in 2001. In our prioritization the site recommendation is more important than the license application at this time in prioritizing the work. However, it is probable that if the budget reductions are significant, our current program schedule milestones will have to be adjusted.

Now, turning to legislation. In June, I spoke to you about the comprehensive bills on the management of spent fuel and nuclear waste that were introduced in both houses of Congress; H.R. 45 and S. 1287. While both bills have been passed by their respective committees, there has been no formal activity since then on either bill. There is an understanding that some of the proponents of S. 1287 would like to bring it to the floor this month or next month. There's a lot of important business before the Congress and I'm not sure when that will be addressed, you know, if it will be, and in this time period. The Administration opposed H.R. 45 because it would place interim storage facility in Nevada prior to completion of the scientific and technical work necessary to determine if a final repository be located there. While the Administration has not developed an official position on S. 1287, the Secretary has emphasized the Administration's objection to any bill that precludes the EPA from establishing standards for Yucca Mountain which S. 1287 in its present state would do.

Now, turning to Board reports. We will issue shortly the two reports the Board issued in April on the viability assessment and the Board's '98 activities. They've been completed by our office and they are awaiting clearance in the Secretary's office. So, I suspect in the next couple days we will send those to you. We have just responded to your July letter regarding our evaluation of alternative repository designs and are preparing the response to your August letter on the scientific investigations on the program. Related to the Board's comments on alternative designs, I would like to now discuss some of the background on what we've done on the selection of an alternative design.

We appreciate the Board's recognition that a comprehensive and resource intensive effort conducted by our management operating Management and Operating contractor has resulted in a much better understanding of the relative importance of the many factors involved in repository design. We have used the results from this evaluation of alternative designs and the results of subsequently analyses performed by the M&O, as well as policy program considerations to select the next generation design concept that will be used in developing our evaluation for the site recommendation. This decision is based on the technical work of the M&O integrated with programmatic policy considerations of flexibility, fairness, and equity within and between generations.

We agree with the Board the repository design concept and, in particular, the temperature regime associated with that concept, can effect the cumulative uncertainty in estimates of long-term repository performance. We also recognize that this uncertainty may affect the confidence and decisions regarding the suitability of the Yucca Mountain site. We have sought to select a design to specify conditions on the implementation that are responsive to the Board's concern while balancing all significant factors including long-term public safety, inter- and intra-generational equity, worker safety, and cost. We have emphasized the need for flexibility to insure that the scientific and engineering data gathered throughout the site characterization, construction, operation, and monitoring, as well as evolution in national policies can be accommodated through reasonable changes in the repository design or the repository operational concept.

The concept we selected is based on the design alternatives recommended by TRW, but also includes the following, flexibility-enhancing conditions on its implementation.

One, the design will permit the repository to be kept open with only routine maintenance for approximately 125 years from initiation of waste emplacement which is approximately the time necessary for the ventilation system to remove sufficient heat to keep the drift walls below boiling following closure.

Two, the design will permit the repository to be closed during the period from 50 years to approximately 125 years or more from the start of waste emplacement. The design will not preclude keeping the repository open, with appropriate maintenance and monitoring, for up to 300 years following initiation of waste emplacement.

Three, the sensitivity of postclosure performance in the repository system to uncertainties associated with a coupled thermally-driven processes will be examined for preclosure ventilation durations of 50 and also 125 years.

The models that are the basis for the evaluation of the thermal conditions will be refined to reduce conservatism. The design options that can increase the efficiency of heat removal will also be evaluated as we go forward.

The selected design concept provides the flexibility to adjust emplacement conditions and the ventilation design and the duration of that ventilation to keep the rock temperatures below 96 and as cool as reasonably achievable given the technical, institutional, and cost considerations. It also provides the flexibility to increase rock temperatures should new scientific and engineering data show that such an alternative would be beneficial.

The design concept we selected also preserves the flexibility for future generations to determine whether to close the repository promptly or to keep it open for as long as 300 years with appropriate maintenance and monitoring based on their judgments regarding the significance of the uncertainties. The closure assumption of 50 years is consistent with the retrievability period required by the Nuclear Regulatory Commission and should provide adequate time to complete the performance confirmation program prior to repository closure.

Now, I would like to turn to our site recommendation program. The program is now working toward completing the technical documentation necessary to evaluate the site suitability to support a Secretarial decision of whether or not to recommend the site to the President. Our selection of the next generation design concept was a significant step in that goal. We are updating the repository safety strategy and refocusing our site characterization efforts to reflect this design evolution. We expect that some work planned in the viability assessment can logically be eliminated or deferred to the performance confirmation program as a result of our design enhancements. we are emphasizing science and engineering activities that most effectively reduce the level of uncertainty in the performance of the repository and which are also needed to improve our confidence in decisions regarding this suitability of the Yucca Mountain site.

We are continuing to gather and analyze relevant data, some of which you will hear about later today from Mark Peters. Following completion of the detailed process models to describe the system performance and the abstraction of these models that are used in a performance assessment, we will generate another major iteration of the total systems performance assessment. This information will be the basis for the site recommendation consideration report which we plan to issue for public comment in November of 2000. We will then refine the process models and the total system performance assessment and use the refinements, together with the comments from the public, the States, the Native American Indian Tribes, Nuclear Regulatory Commission, and this Board as input in that process in those final revisions.

The program's work remains focused on the activities that we feel are most important to developing the information needed to determine if the site is suitable, and if suitable, support the Secretary's decision on whether or not to recommend the site to the President. The viability assessment followed by our selection of a design concept for the next phase of the project activities and the corresponding update of the repository safety strategy has clarified the remaining work and illuminated those technical issues that need to be further addressed. We have started this remaining work, and input from this Board regarding the technical and scientific validity of these efforts will be very important as we proceed toward the completion of the site characterization phase of this program.

Those conclude my remarks and I would be pleased to address any questions that the Board may have.

COHON: Thank you very much, Lake. I just want to emphasize for the record that we have a wonderful new design standard as cool as reasonably achievable which, in fact, of course, you know, fashion designers have been following for many years and now DOE has caught up. That's great.

Let me just use the prerogative of the Chair to ask you a question. It's good to hear that you're going through the effort of prioritizing activities in light of the uncertain budget situation. Could you tell us what happens if you get the House number?

BARRETT: That would be a significant budget reduction which would result in schedule changes. Our approach on this is to prioritize the work to support the first national decision which is the suitability of the site which we think is the most important and defer license application work that we can catch up. For example, we've already taken steps within the family and that includes the TRW contractors to defer preclosure work that's necessary for a license application. So, we're expecting somewhere between the 280 and the 355. We are hoping that it's very close to the center mark in the mid-300s. With that, we believe that we would defer the preclosure work and can basically maintain the set of necessary scientific postclosure work which includes the natural sciences and corrosion, things that the Board is focusing on, to hold the site recommendation to schedule. As you start to go below, say, the 340 or 330 usable money--this is after you take the State and the County monies out which will be a national policy statutory decision; we've asked for that money--then, we may have to start deferring the site recommendation depending on what it is. So, we'll have to look and see where that would be. We have said that if we get the 380, we believe we can get the 380 level, we can probably come close to minimal delay on the license application and catch back up. If it starts to impact the site suitability postclosure, that is hard to catch back up again. So, we'd see slips ranging up to a year.

Now, the House situation at 281, we would have to reduce staff by almost 1,000 people--we have about 2200 or so on the staff now--the reason being, there's termination costs. So, when you have to come down that much, it is very significant impacts. I would expect that a license application on that scenario would be delayed about a year and very likely the suitability would be delayed a commensurate amount also because our first three months are going to be just basically keeping from being anti-deficient. We went through this back in '96. It was traumatic then and this would be traumatic again if that case were to happen. I am very hopeful that the House of Representatives can deal with their allocation issues and that the results will be something closer to the Senate situation. We are all very hopeful of that, but we'll have to wait and see what happens over the next several weeks.

COHON: Thank you, Lake. Other questions from Board members? Debra Knopman?

KNOPMAN: I don't want to go through every budget item, Lake, but I think it would be helpful to clarify where something like further work on transportation studies routing would come in under these various budget scenarios that you've just gone through.

BARRETT: You know, we're trying to hold the site recommendation schedule. The site recommendation schedule requires the final Environmental Impact Statement to be done. We are funding the hearing process. I think we're going to have, you know, 17 public hearings we're going to do. We will have public information meetings, you know, basically as requested and a reasonable request we will grant. So, what's necessary to support to the FEIS is a high-priority work. It goes with the site recommendation. We need to have a balanced program. I referred to this to staff. It's sort of like a chain picking up a heavy load. You want to make every link of the chain the same strength. If you have one length that's bigger than the other link, it doesn't matter and the chain is only as strong as the weakest link. So, the FEIS work needs to be supported for going on with site recommendation along with, say, the natural sciences, the engineering, the whole thing.

So, as far as additional transportation work, we will do what's necessary for the FEIS and we'll go into the public hearing process.

COHON: Dan Bullen?

BULLEN: Lake, when you introduce a concept or a term like "as cool as reasonably achievable", you immediately draw a parallel to as low as reasonably achievable with respect to dose base protection and radiation workers and the public. And, I guess, the question that I raise and maybe it will be answered in later presentations, is how do you define what reasonable might be? Do you do a risk basis estimate using the performance assessment models or does it turn out to be a cost benefit analysis? What kinds of things define reasonable or how do you envision reasonable to be defined for as cool as reasonably achievable?

BARRETT: That's what we did as we went through this. We didn't put $1000 per man-rem, and those of you who can go back to Appendix I to Part 50 through, you know, those kinds of days, it is not a quantitative analysis. You cannot quantify these. It is a qualitative judgment where you are balancing the programmatic flexibility considerations. Following the Board's letter from July, we did this in an open documented way. That is in the Board actions that I've signed to balance that. That's really what it is. It is not an analysis, per se; it is a judgment that is written down as to why we chose and we weigh very heavily the flexibility for future generations in that and not to foreclose options through a design requirement at this time. There is not a mathematical algorithm of the old $1000 per man-rem and that never worked then and it doesn't work now.

BULLEN: Thank you.

COHON: Other questions? Richard Parizek?

PARIZEK: It's a question about the selection activities that might be postponed for a validation stage. Some of this might be dealing with some uncertainty, some of it might be work that you really couldn't do up front, but may be quite critical as to when it may create some uncertainty about the suitability of a site. You've got to make a recommendation about suitability on schedule. If you postpone some activities until after site recommendation, that might be the fatal flaw or create a great uncertainty, you know, in the program. Kind of sort that out. Will we hear about your priorities and how these are decided upon at this stage because it's quite critical?

BARRETT: Yes.

PARIZEK: --sure that at the end point that you haven't postponed some key things that really should have been addressed up front before site recommendation.

BARRETT: Yes, you'll hear more about that as basically it's the application of the repository safety strategy. It's kind of where that shows as we're guided by the TSPA work and the uncertainties in the TSPA, as the Board has pointed out. We desired to do the $409 million suite of work. Well, our desire is not being met. Very seldom in life do I find in my personal situation that my desire is always met. Now, can we do what is necessary for a suitability? Now, what is necessary? We must do that floor. Now, what is necessary versus what is desirable? And, desirable can be put into the performance confirmation because this is an easily reversible process. So, as we make a very important national decision if the site is suitable and go through that political process as laid out in the Act, that is a very solemn decision. But, it is not a reversible decision if science tells us something different. But, there must be adequate uncertainty to sustain that decision for us to recommend to the Secretary, the Secretary to recommend to the President, for the State of Nevada Governor and the State Legislature to do their actions. So, we need to have an adequate base. We're all struggling. I'll say we are struggling trying to determine what is the most important, what is the absolutely necessary work that must be done, what is desirable in confirmatory work that can be done later? And, we don't know quite at what level--if it's 340, 330, 320--where we say, no, in our judgment we did not do the necessary work for the suitability. So, we have deferred almost all other activities focusing on basically the postclosure regime. Prioritization is to do the suitability which includes doing the FEIS, but we've deferred pretty much all general transportation work. We've deferred almost all repository surface work. I am trying to do all my issues dealing with the lawsuits and the utilities with just a very small skeleton staff in Washington and trying to isolate the Yucca Mountain Project from that trauma so they can focus on Job One which is are we doing sufficient scientific work to address the suitability.

The Board's views, I think, is extremely important and this is a very timely meeting as we are basically getting our algorithms together so that we do the most important work and then we're going to decide after we do the most important work is that work sufficient to support that decision? That's the process we're going through this fall. So, it's timely that you see, what I call, the application of the repository safety strategy using the TSPA and the prioritization of the work. And, we must and I think the Board in all practical purposes, if we're not satisfied that we've done the necessary work, then the suitability decision would have to be deferred until the necessary work can be done.

COHON: Thank you very much, Lake.

BARRETT: Thank you.

COHON: I call on now Ray Clark to talk about the EPA standard. Ray Clark is a Captain in the U.S. Public Health Service who has been detailed to the U.S. EPA in the Office of Radiation and Indoor Air. Welcome, Captain Clark.

CLARK: I'd like to thank the Board for inviting us here today. It's been long in coming, but it's finally here. It was nice to hear Lake say that EPA has proposed a standard rather than when EPA proposes a standard.

Before I get started, I wanted to recognize two of the people from my office that are here with me. Dr. Ken Czyscinski is in the back back here. He's our geologist/geochemist. Frank Marcinowski is the acting center director for Center for Waste Management and Deputy Director of the Radiation Protection Division.

Since you squeezed us into the agenda anyway, I'll really try to fly through these. I'll provide a very short background on how we got to Yucca Mountain Standards, go through some of the provisions and a little bit of the rationale on how we reached the proposed standards that we have, and then very quickly the plans for the future of the final standards.

As the Chairman said earlier, the Energy Policy Act, of course, gave us the authority to set these site-specific standards. I was also told that the contract was a National Academy of Sciences to provide technical recommendations on the bases for the standards. We did do that. They gave us their findings and recommendations and

I'll mention that a little bit later. Finally, the NRC licensing regulations which have now turned into Part 63 are to be consistent with the EPA standards. We did propose those, at least published in the Federal Register on August 27.

One of the earliest questions that came up in our deliberations was how do we take into account the NAS report? The Energy Policy Act said that our standards were supposed to be based on and consistent with the NAS findings. We finally arrived at the conclusion that we were not absolutely bound to what the NAS said, but of course, do weigh heavily, particularly in the technical areas where NAS is obviously the strongest. The NAS panel did help us out because they did a fairly careful job of separating policy from technical issues, at least that was our impression. So, therefore, a lot of their findings were written as suggestions or as thou shalt or thou shalt not.

The second thing was that Congress directed us to set standards by rule. So, by that, we think by rule usually means you go through a public rulemaking process, and obviously if you're familiar with the report, there are many places where they tell us or the NAS even says go through a rulemaking.

The final thing is that setting standards such as this is a federal function and not getting high-handed here, but if we were to assume that whatever NAS said was a standard, it's possibly getting into constitutional issues. But, I'm certainly not a lawyer, I'm not an engineer, as I said. So, those are the bases of how we weigh the NAS report.

A big consideration also is our Part 191 generic standards which, of course, do set a precedent for protection. They have been used for certification of the WIPP facility and also being used for approval of the greater confinement disposal facility.

Getting to the standards themselves, as you can see, we have two subparts, one storage and one disposal. The NAS didn't address storage, at all, in their report. For disposal, individual protection standards, human intrusion standards, groundwater protection, and a couple of other provisions that limit some of the considerations. As far as storage, storage is also taken to mean as management both on the surface and in the repository itself. The proposed standard is 150 microsieverts or 15 millirem for the English speaking people in the crowd. That is committed effective dose equivalent. We divided the applicability of rules between in the repository and outside the repository. Again, a legal interpretation, the Energy Policy Act says that we're supposed to set standards for storage and disposal in the repository. So, we took that literally. So, the new standards would cover storage in the repository or management. The Part 191 generic storage standards cover the surface operations that occur within the Yucca Mountain site. Those two would be combined and that's what would be compared with the 15 millirem standard.

This level--and we'll get into this again shortly and I'll just point it out now--is also consistent with Part 191, of course, since we're using it and it's also the NAS suggested annual risk level of 10^{-6} to 10^{-5} which is 20 to 200 microsieverts at least in our system.

Moving on to the disposal standards which is probably of more interest here than the other, again we have 150 microsieverts under the effective dose through all pathways over 10,000 years. One place we've not followed the NAS recommendation was we've used what we've called a reasonably maximally exposed individual as opposed to a critical group which is what NAS recommended. This individual is a theoretical person who is in the highest exposed group--and this is the theory behind it--in the highest exposed group, but not the maximally exposed individual. We're trying to keep analyses into what would be reasonably expected in an actual situation. The way you arrive at that is to set one or a few of your parameter values at their maximum. These are the exposure parameters and set the rest at a mean or median value, an average value.

So, what we've proposed is that this individual be located near the Lathrop Wells intersection. I suspect most people here know roughly where that is. It's about 20 kilometers south of the repository. We think that using this method of calculating a dose puts you in the same place as the critical group approach that NAS recommended. The other reason for not using critical group is because EPA has never used it in the past; however, there have been programs which have used reasonably maximum individual in other areas of the agency. We'll get to that in a minute. This person would be representative of the current residents in Amargosa Valley; in other words, physiology, lifestyle, all those sorts of factors that are considered. One of the maximum values that we would direct is that they drink two liters per day of groundwater. I should point out, I guess, that this Lathrop Wells is also one of the other factors that would be considered to be one of the maximum parameter values.

I've already touched on a little bit of this. In fact, probably most of it. This gives just a little more explanation of why we chose RMEI rather than critical group and I think I've hit on most of that. In the interest of time, we'll skip on to the next one.

Human intrusion standards. Here, the NAS said human intrusion or assumed human intrusion will occur. It's just you can't do a--well, remove it from a probabilistic assessment. Just assume that it occurs and it occurs once or twice or whatever you recommend and do the analysis to test the resilience of the repository. And, here's a place where they recommended that we use public rulemaking process to establish this scenario. The limit that we've put on this which again follows NAS recommendation is 150 microsieverts per year--that should be CEDE, as well; I see that got left off--within 10,000 years. The scenario is a single intrusion through a waste package as a result of water exploration. We specifically say water exploration to set some sort of a limit on borehole size. Borehole goes clear to the aquifer and you assume that it is not carefully sealed. The timing in our scenario, the intrusion would occur as soon as the canister or waste package, more properly I guess, is sufficiently degraded that the drillers wouldn't recognize that there's a waste package there. I guess to follow up on that a little bit, in other words, we didn't set a particular time for the intrusion. It would be up to DOE and NRC working together to establish that.

An alternative approach is also in the proposal.

It depends on the timing of the intrusion which, in turn, depends on the corrosion of the canister, of course. This intrusion could not occur prior to the 10,000 years. We would require DOE to put the results of their analyses in the Yucca Mountain EIS. Now, obviously, we probably wouldn't get them to put it in the first draft of the EIS, but presumably there will be a final EIS, as well as most likely supplemental EISs as time goes along. This would not require NRC consideration if it was shown to occur after 10,000 years in the licensing application, at least.

One of the more fun ones, groundwater protection standards. We've proposed the limits to be the maximum contaminant levels as established under the Safe Drinking Water Act. These are the same limits that are established or used by the agency in other programs, non-radioactive waste disposal and various other areas. These would be in a representative volume of groundwater and we will get to that in a minute or two what that means. That bottom bullet just lists the MCLs.

Why have separate groundwater standards, a question we've been asked once or twice. First of all, it's the Administration policy to protect ground water and the way that is currently being done is to use the MCLs as groundwater protection. The intent is to protect the current and future uses of the resource. Part of the philosophy is also it's a lot easier to prevent the contamination than to try to detect it, especially in a large aquifer--well, I'm sorry, in an aquifer and it's also cheaper to do that rather than having a facility declared possibly a SuperFund cleanup site or something in the future and then try to go in and clean that up. It's also, as I mentioned earlier, consistent with other programs. Part 191 has separate groundwater standards. The WIPP certification was based on Part 191. So, therefore, it used groundwater standards. The GCD program is subject to some groundwater standards; albeit not in the same form, there is provision there. Hazardous and municipal waste disposal, as I referred to earlier on the underground injection control program, all use MCLs as examples.

What's this thing, representative volume of groundwater? What are they doing now? Realizing that it's difficult to model groundwater, particularly in a fractured medium, we said it was reasonable to come up with a method to reasonably implement the groundwater standards. How we came up with this concept, what it is it's the volume of groundwater withdrawn to meet a specified demand. We'll get to the specified demand in a minute. It would be centered on the highest concentration in the plume. It's position and dimensions would be based upon average hydrologic properties along the flow path rather than trying to pinpoint what the actual characteristics are right at whatever particular point is chosen.

We've proposed two ways to calculate the dimensions of this representative volume. One is a well-capture zone. In other words, you have a well pumping water out so many acre-feet per year. Or a little slice of the plume in which you actually take or model part of the plume that equals the relevant water that we'll discuss in a minute that's in the representative volume. How you dilute the--if it turns out to be dilute--the releases into that volume and use that for your calculation.

We've proposed a representative volume of 1285 acre-feet per year exactly. I know that sounds awfully specific. What we did was we assumed a small farming community of roughly 25 people and this farming community had 255 acres of alfalfa. Now, based on the information that we have, that's the average size of the alfalfa operations in Amargosa Valley. They use five acre-feet per year of water out there again according to the information we could find. So, that leaves us with 1275 acre-feet per year. Then, you have a family of four that could have domestic uses including a garden. So, that adds the other 10. So, that's the basis of the 1285.

We also have some other alternatives in the standard that range from 10 to 4,000 acre-feet per year. The 10 is the minimum volume of water for a public water supply. So, that's obviously the bottom of where we would protect. 120 is based on this 150 person community and it's also based on the current water use in the Amargosa Valley/Lathrop Wells area and a short term projection of land use up in that area. 4,000 acre-feet is the annual yield of Jackass Flats sub-basin. I was going to say perennial, but it says annual; so, I'll say annual.

There are four alternatives for the groundwater compliance point. Here, I apologize. I hope you got the handout of the map. It got left out of the package, the thing that looks like that. There are two methods of approaching this that we've proposed. One is a controlled area which if you're referring with Part 191 we use controlled area. The other is designated point together with fixed distance alternative which I'll explain. The first area--and this is courtesy of DOE; so, I've used the earlier drawing of the Part 191--a five kilometer area, is precisely that. It's just brought over from Part 191. So, presumably, you'd have an area similar to this for the five kilometer option. The other controlled area option is a combination of five kilometers in the Nevada Test Site. It is a five kilometer distance around the footprint. This is obviously for illustration only. I'm also not an artist. But, what happens is in your five kilometer distance where it intersects the Nevada Test Site boundary, that becomes the controlled area. So, your controlled area for that option looks like that. We refer to that as the 18-kilometer alternative assuming that this is about 18 kilometers down to here.

The two designated points fixed distance, one is Lathrop Wells which is roughly 20 kilometers. The other is an area down here in southern Amargosa Valley where most of the agriculture takes place. We would have DOE and NRC to determine a point within that area for the compliance point. The fixed distance alternative would be the fact that we've assumed the groundwater is going to be on--for illustration purposes coming down this direction. If somehow that higher concentration comes over here, we'd obviously want to avoid the situation where--well, concentration at Lathrop Wells is zero. So, that's fine. What we would do at that point is, say, use the same distance, but draw an arc to wherever that concentration would intersect it; the same thing down with the 30 kilometer option.

The other provisions that were in the outlying chart earlier, post-10,000 year results for individual protection. The NAS did recommend peak dose within geologic stability time of the repository. So, we wanted to address that; however, we were also concerned about the uncertainties that occur after 10,000 years. So, what we've proposed to do that is you do the 10,000 year analysis as a regulatory requirement, you calculate on out after 10,000 years to the peak dose, and again include the results in the Yucca Mountain EIS. This is intended to be just an indicator of future performance. So, nothing really crazy happens out there.

The second requirement is just a limit on performance assessment considerations. This is the same as in the general standards in Part 191; you need only to consider process and events with probabilities. Critical event are equal to 10^{-8} per year.

I'm not flying very well. So, I'll try to pick this up. All our standards in Subpart B are based on the concept of reasonable expectation. Our whole approach here has tried to be reasonable. The RMEI, for example, is not the maximally exposed individual, but hopefully a realistic dose that could occur out in the population. Likewise, our other standards are based on this reasonable expectation. This is the same concept we used in Part 191. Our intent here is that it's taking into account the uncertainties in long-term projections and we also mean it to be less stringent than the concept of reasonable assurance which has been used in the reactor licensing business. Obviously, a 40 year lifetime on an engineered system is different uncertainty-wise than the 10,000 year projection on a geologic system.

We're still leaning toward to include all important processes and parameters, but the important point is even if they're not precisely quantifiable, if there's a barrier or a geologic feature that could add to the safety of the repository, use some reasonable bounds. Just because you can't say it's 10^{-3}, da-da-da, still consult the science-- well, I'm not doing well here. Consider the findings and use a reasonable bound. That's all I'm trying to get to in that. The compliance determination should not be heavily influenced by worst case assumptions. In other words, don't always take the extreme ones or the distributions and compound them. Use the entire range of those distributions. That's what I was trying to say before, as well, and that covers the last point, as well.

And, mercifully, the final or next to the last slide, public hearings are currently scheduled for next month in Washington here on the 13th; Amargosa Valley on the 19th;

Las Vegas, the 20 and 21st; a midwest location which is not yet quite nailed down for the final week of October. Comment period is open until November 26. We, of course, will do a response to comments document and final technical background documents which are background information documents which is our version of an EIS in a sense, but it's just technical information and also an economic evaluation. Target for final is a year after proposal.

Now, a slide you don't have and I apologize to the non-physicists in the group. It's speaking of uncertainty. I found this and I couldn't resist it. That concludes what I have.

COHON: Thank you, Captain Clark. Let me ask you a logistical questions before we get into a substance. We have approximately 10 minutes left in this part of our meeting and I probably have more than 10 minutes worth of questions myself and I expect there will be more. Are you able to stay with us until noon or so today? That's putting you on the spot. You can say no.

CLARK: I'll try and stay for a while.

COHON: Well, the reason I asked about noon is that we must take on the next two presentations that will last until approximately 11:30. At that time, we have a public comment period and I expect there will be public comments, as well as additional Board questions about the standard. So, if you can't stay until noon, then there's no point staying until 11:30 either unless, of course, you want to listen to the wonderful presentations. All right. Well, please, consider that and let's not waste the rest of our 10 minutes here on this.

Paul Craig?

CRAIG: Ray, I'd like to ask you whether EPA has issued other standards that allow doses to increase above those permitted? Has EPA issued other standards that allow doses to increase above the permitted level at some period of time? What I'm specifically referring to is the way in which you dealt with the academy recommendations that doses be set for the time of peak dose. One could envision doing a peak dose standard taking into account the growth of uncertainty beyond the 10,000 year limit. Well, you rejected the academy proposal for doing a peak dose standard and my question is whether there exists other instances where you allow--where you anticipate that the dose will rise above the permitted level at some time outside the regulatory time standard, time specification. This is an unusual situation where at the time of your regulatory limit based on the analysis that DOE has done, you expect the doses to be increasing and increasing substantially.

CLARK: I stand to be correct on this, but to my knowledge, we've just never addressed that for 10,000 years, whatsoever. So, it's not necessarily that you didn't expect doses to increase.

CRAIG: But, you said something about uncertainty. I'm not supposed to consider uncertainty?

CLARK: --based it on the uncertainty becoming a problem for decision makers to try to make a reasonable determination after that time. So, here, we were just trying to address the long-term possibility and recognizing the NAS recommendation.

COHON: That sounds like no. With apologies to Lake Barrett. We had asked him to be prepared to comment if he so chose on the proposed standard and I forgot to call on him. May I call on you now, Lake? Do you have comments to make at this point?

BARRETT: Just very briefly, I mean, I think my remarks earlier stand that we want to have a demonstrable standard that protects the public health and safety and environmental that's demonstrable in the rigorous license proceeding. As you heard and Ray presented, there are many options and combinations in the proposed standard. Some of those, we believe, would be reasonably implementable. Some of those, we feel, may be going beyond what science and technology could ever demonstrate.

Picking up on Paul's remarks, if you project out to nominally a million years and have low numbers, the uncertainty becomes so high you can't do it and then you reach a situation where having a standard would basically foreclose geologic disposition in any fresh water site. You're starting to make a decision and then you need to start looking at sort of the no action alternative situation we had in DEIS. The only thing we've ever evaluated in this program that ever had environmental impacts that we believed were major and significant are those in the no action alternative where you did not responsibly manage the material. In the far future in the no action alternative, we've lost institutional control where you had big doses.

So, I think as a society we must be very careful that we don't set a standard that is beyond what science and technology can do, but yet must be a reasonable standard and await EPA as going through the process that they're going through. So, we will provide our comments in the hearings and in the official thing, but we're just very concerned that a priori we don't set a standard that's impossible to meet and especially considering the Board's views of uncertainties and we must consider the uncertainties as we go forward.

COHON: Thank you, Lake. Dan Bullen?

BULLEN: First, just a comment and I know this is a little bit absurd, but in the intruder scenario that I know you have to do, it's always amazing to me that somebody is going to drill for water from the top of a mountain. Okay? That just strikes me as one of those things that's a little bit absurd.

But, actually, as a followon to that, could you comment on the maximum concentration levels for groundwater protection? Specifically, what fraction of existing municipal water supplies meet or maybe what fraction fail to meet due to naturally occurring radioactive materials the standards that you set for Yucca Mountain?

CLARK: To get you a real number, I'd have to get back to you on that. For the beta/gamma, it's only manmade. That's the four millirem part. As far as the alpha, I'd have to check. I don't know.

BULLEN: I'm just curious about that because, I mean, that's one of the sticklers that people have with respect to making the four millirems is that, you know, if there's naturally occurring radioisotopes that--I mean, I don't see the difference between a naturally occurring radiation exposure and a manmade radiation exposure. And so, you know, the stringent standard for MCLs in the groundwater are probably pretty challenging.

CLARK: Well, as I say, the four millirem is just manmade beta/gamma. It doesn't consider background. That's just the way they are set up, you know, just--well, before my time is the way that is. But, you're correct, the alpha does include background. At this point, I don't think we see alpha as getting down that far, but--I mean, if it's five kilometers, we'd have to see.

COHON: Dan, do you want a written response to that question?

BULLEN: Actually, I'd like to see the numbers if they've got them. I'm pretty sure that when the Clean Drinking Water Act was revised in the early '90s, those numbers were published in the Federal Register somewhere.

COHON: Okay. Thank you. Jeff Wong?

WONG: This is a promised question, Ray. How do you envision the two standards interacting? Do you see a situation which either standard might act alone in demanding repository performance? Two questions, so far.

CLARK: I might have to get back on your second one. By the two standards, you mean individual protection and the groundwater?

WONG: Right.

CLARK: Not given intrusion?

WONG: Groundwater and individual protection.

CLARK: Okay. Well, we see both of them as protecting what they're intended to protect. Individual protection is required to protect individuals; groundwater is to protect the resource as such even though we use a dose number to do that. The individual protection requirement was established on a risk level which I mentioned in there earlier. The MCLs were established under the Safe Drinking Water Act and is the current law at this point. My understanding is it's a policy decision to apply separate groundwater standards, but they're intended to protect two different things. --intends to be limiting the other.

COHON: Jeff, if I could just interject because I have a similar question. You just said in passing that the groundwater standard uses dose considerations to arrive at a standard. Wouldn't one expect then consistency between the groundwater standard and the 15 millirem standard?

CLARK: I guess I need to know what you mean by consistency between the MCLs for drinking water. It's the drinking water pathway. The individual protection is all pathways. So, there is that one pathway.

COHON: Well, both are filled, especially the groundwater protection--the application of groundwater protection standard is filled with assumptions about various scenarios. People living in certain places using a certain amount of water or for certain purposes. Similar assumptions are made arriving at the 15 millirem per year standard. That is the two liters per day water consumption, for example. I would think that it would be desirable to have consistency in that sense that there's some linkage here.

CLARK: Well, with the different alternatives, we might have to have different locations. Is that what you mean; the same person using the same water or would that be a--

COHON: No, I think I made my point for the record. Jeff, did you have more questions?

WONG: I have one more question. You say you're going to use the RMEI instead of the critical group to avoid the most extreme cases. I assume that's related to dose projections. But, in your bullet that's on Page 8, you say you're doing to use a mixture of 95 percentile and average values for the exposure parameters. I assume that's for other biosphere parameters, also. What's your expectations on how you or NRC or DOE will decide what parameter they'll use the 95 percentile value and what values they'll use the average value?

CLARK: Well, for that purpose, first of all, we weren't using our RMEI instead of the critical group to not do the maximally exposed. They're both approaches that would not use maximally exposed if I heard you say that right. We have proposed two parameter values as maximums. The Lathrop Wells location and the two liters per day. After that, it's up to the commission as an implementing decision whether to do more than that or not. It's their prerogative.

WONG: So, again, on Viewgraph 8, the use of the mixture of 95 percentile and average values for exposure parameters, you're going to leave it up to the NRC to tell the DOE which they're supposed to use?

CLARK: With the exception of the two that I mentioned, yeah, uh-huh.

WONG: All right. Thank you.

COHON: Thank you. Let me just do a quick time check. I know we have questions from Alberto and Debra. Are there any other members? Well, let's push on for five minutes, and wherever we are, we're going to end in five minutes. Okay? Actually, I think Debra was next; Debra and then Alberto and then Richard.

KNOPMAN: Could you tell us how much EPA when back and examined the underlying biological, physical basis for the standards for low radiation exposures in the first place? There is a report in the September issue of "Physics Today" about a UN committee going back and reexamining the underlying assumptions that go into standards used worldwide for exposure to radiation. I'm wondering how much EPA decided to just take what is conventional practice or how much time you spent going back and looking at what actual health effects there are at these various levels.

CLARK: As far as the Yucca Mountain standards project did, we don't do that personally. We have a group that is a bio-effects analysis group who are continually reviewing new information and reviewing what they've already looked at relative to the new information and are continually updating the information they give to us to use. So, they're, at least to my knowledge, well-aware of everything that's going on, as well as the history of what's gone on before.

KNOPMAN: So, that was not a point of discussion or debate as to whether or not to proceed with using the current international standards?

CLARK: Well, that might be a little different. Certainly, we considered other standards, if I'm understanding you right. Rather than the bio-effects, you mean the other dose standards or--

KNOPMAN: Well, based on what you presume the biological effect to be of radiation.

CLARK: Oh, that's agency policy.

COHON: Thank you. Alberto Sagüés for a very brief, to the point question.

SAGÜÉS: Yeah. On your transparency #10, there's a statement to the effect that if intrusion could not occur--

CLARK: Uh-huh?

SAGÜÉS: Yeah, how could intrusion not occur?

CLARK: That's based on our condition that we've imposed that the canister or the waste package had not degraded enough for the driller to not know. So, if the driller hits a waste package and the bit deflects or they have a lot of trouble getting through the package more than they would expect, we would consider that they recognize there's something there that's not normal. Therefore, the intrusion would not have occurred. If the time that it occurs is once the package has degraded enough that the water drill bit could pass through that area without recognizing there is a waste package there. So, what's what we mean by could not.

SAGÜÉS: I see.

CLARK: That it would not be recognized by the drillers.

SAGÜÉS: And, the second part of the statement, the results of the assessments and their bases must be placed into the Yucca Mountain environmental impact statement, wouldn't they be placed anyway or--

CLARK: I don't know whether they would or not. I haven't examined the draft EIS all that much, but I don't think that's there at the moment. But, that's something we think is important to be in there.

SAGÜÉS: All right. Thank you.

COHON: Thank you. Richard Parizek?

PARIZEK: I was looking for other limits on drinking water and I only find total dissolved solids mentioned in one place. Do you have like iron and lead and zinc and copper and so on in the plan? I don't see it mentioned anywhere except as total dissolved solids, and on Page 11 of the viewgraph, you talk about MCLs, but it seems all radionuclide related.

CLARK: That's correct. Those are just a radiation protection standard and we're not using the false lead of MCLs now.

PARIZEK: Okay.

COHON: Thank you very much, Captain Clark. If your schedule permits you to stay, we would appreciate it, but we'd certainly understand if you're not able to.

We will now take a break for seven minutes. The next session will be chaired by Debra Knopman who will call us to order in seven minutes. Thank you and thank you to all of our speakers.

(Whereupon, a brief recess was taken.)

KNOPMAN: We're now going to begin the portion of our meeting devoted to understanding the evolving repository safety strategy and we will, however, start with an overview of the Yucca Mountain Project by Steve Brocoum. Steve is the assistant manager and in charge of the Office of Licensing & Regulatory Compliance at the Yucca Mountain Site Characterization Office.

BROCOUM: Okay. I'm just going to give an overview of the perspective on Yucca Mountain. We're going to talk a little bit about some new people on the projects, what we did in '99, what our priorities are for fiscal year 2000, implementation of what our enhances are in Alternative II and an overview on the planned testing, a few words on repository safety strategy which will be talked about in detail, as will be the planned testing, and where we are in our EIS process right now.

We are continuing to implement our culture of excellence. We informally call it nuclear culture. We've tried to enhance our project management practices to become more efficient, to become more traceable, to become more transparent, and we've put a lot of effort into that this year. The project manager, Russ Dyer, has proposed a two deputy organizational structure for Yucca Mountain. It's proposed at this point with Don Horton would be the deputy for technical, and Linda Bauer who was just shown the project a month or so ago in Hanford will be the operations deputy. Secondly, the vacancy for the assistant manager for the

Office of Project Execution was filled by Suzane Mellington and she came from Oak Ridge. Suzane Mellington and myself report to Don Horton.

For '99, things that we've done from '99, we issued VA in December. I think that's very low impact here. We completed and released the technical basis report last December. We released the site description in January. We released the draft Environmental Impact Statement in August. Just this Friday, Lake signed for the program, the design concept, EDA II, and he sent a letter to the Board.

Where do we go in the fiscal year 2000? One of the key things we're doing is implementing a quality initiative of trying to resolve the issues we've had and the corrective actions for our qualification data and our model validation. The NRC has made it pretty clear that unless we get a lot of that well on its way to resolution, then when it comes time for them to make sufficiency comments on our site recommendation, we might have some issues that they might produce. So, we have to really work on that. But, we're also going to do it for ourselves to get our program in good shape.

We are preparing--and you're going to hear a lot about this over the next two days--Process Model Reports which are key inputs to the TSPA and the system description documents for the design inputs that we're going to use for next version of the TSPA and our site recommendation consideration report. And, of course, we're implementing Design Alternatives II, as I mentioned already.

We're conducting testing and there's several presentations on testing to understand our key parameters. We're to complete TSPA-we're at zero--next September or September 2000. We're preparing for fiscal year 2000, the site recommendation consideration report, you know, internally. We're conducting public hearings on the EIS. We're going to work if the hearings are finished on finalizing EIS and we're trying to resolve the status of the DOE siting guidelines for evaluation of suitability for the site recommendation.

The acting director, Lake, has approved the M&O recommendation. Lake talked about this a little bit. So, I really won't go over it. The key thing is that we added some conditions that the closure could occur between 50 and 125 years. At 50 years, some of the rock around the drifts will be above boiling. At approximately 125 years, we don't believe any of the rock would go above boiling, but with maintenance can be kept open for 300 years. This gives a very flexible design as we better understand postclosure thermal conditions and we can modify the design of the future and also allow us the option, as Lake said, if the future generations of the site want to close.

Okay. Our planned testing depends on the needs for a new EDA II. We've got a lot of comments from external oversight groups including the TRV. We keep learning about the site and understanding the site conditions and, of course, the repository safety strategy and how we're going to get to the license application assuming it's site suitable.

You'll hear a lot about testing in the next two days, but basically seepage is one of the big issues and these types of tests here are to address issues on seepage. Again, flow and retardation are big issues at Calico Hills. Drift scale heater tests for hydrothermalogic conditions. A lot of concern about retardation in the saturated zone and that's what the 40 Mile Wash is, in part. Waste package and engineered barrier system are very important in our design. Those need to be understood. Of course, National Analogue studies is one of the key additional confidence builders that we have in our repository safety strategy.

Revision 3 of the RSS is in draft form. We've decided not to finalize just yet until we have a meeting with TRB and get input from the TRB before we finalize it. Currently, we're thinking of finalizing sometime in the middle of October. So, any comments that TRB has would be very useful for us in finalizing this version of a strategy. This, as somebody mentioned, is a little document. This is Rev.3. Next summer, we will have a Rev.4. It will include the updated design, EDA II. It focuses on understanding the principal factors most important to repository performance. There will be a lot of discussion of that of the seven key principal factors. It discusses the approach of adequacy of information and prioritizes future work and describes how to implement TSPA and what we call barrier neutralization analyses.

The EIS, a few words on the EIS. Once the public comment period closes in February, the revised EIS, it goes on the 24th of July into internal headquarters concurrence and we'll plan to publish it on November 17, 2000.

The EIS has been lightly distributed, although we should have been smart and had several copies out on the outside table here in both hard copy and CD-ROM. It's available through our project website, it's available through the DOE Office of NEPA Policy, and it's available by just calling that phone number. All the references are in four reading rooms. The EIS itself is in many, many libraries throughout the country.

When the public notice went out, we had 16 meetings scheduled for the EIS. I understand we're adding a 17th meeting for Carson City public hearings.

This is a very busy chart. I just want to point several things out on this chart. This is our schedule to site recommendation. Today, we are right about here. You'll notice originally we were going to have the repository strategy done by the end of September. That repository safety strategy will be revised for Rev.4 roughly in July of next year. By November of next year, we will have the final EIS. We will have site recommendation hearings and comment notice of hearings. We will ask the NRC for sufficiency comments. We will release the site recommendation consideration report for public review and that will happen next November. We hope to get sufficient comments from the NRC May 25 of '01, and if we stay on schedule, the Secretary will issue a decision roughly June 26 of '01. Those are the key dates. Rev.00, as we call it, of the TSPA comes in on, I guess, August 1, '00 and that feeds the consideration draft. And, Rev.01 of the TSPA comes in April 1 of '01 and that feeds the site recommendation.

This is our pyramid for site recommendation. Working from the bottom up, this is all the detailed information the project has collected over the years. That feeds up into various summary type documents such as the system description, the Process Model Reports, the TSPA-SR, repository safety strategy. The area surrounded by the green is roughly what we will be issuing for the consideration report. Those are prepared by DOE. We're thinking of four volumes. Volume 1, Volume 2 which would be issue the consideration draft, Volume 3 which is summary of views of outside parties, and the Secretary's response, and Volume 4 which is the NRC's sufficiency comments. So, those four volumes we make in our current view of site recommendation.

In the site recommendation consideration report, we would issue Volumes 1 and 2 which should be all a preliminary nature and a status at the time for public comment. But, that's what would come out next November.

Now, adequacy of information, there will be a lot to be said about adequacy of information. I just want to make two points here. First is that we've been studying the site for many, many years. We have about spent $4 billion by the time site characterization is done. We have had enough confidence that new information won't make radical changes to our understanding. If there are radical changes, it seems to me that you're not ready to go into the site recommendation. You have to have enough confidence that new information will not make major changes.

Secondly, you have to be able to put together a defensible compliance position because we need to comply with the regulations that will be in place. We're working very hard and have got extensive documentation. We're working very hard in integrated product, a traceable product, and a defensible product. All of our business practices have improved this year to make sure we can have traceability and improve our transparency.

Process Model Reports and analysis and model reports which feed the process models are very important. It's a way to put all the information together in a structured and controlled environment so that other parties who look at this can see how it's been done. The same with system description documents for design and all of these feed together and are the building blocks of the future TSPA.

This is a larger diagram that, I believe, Lugo will talk about in his talk on PMRs, but it gives you the sequence of events. I felt it a very nice diagram to show the sequence of events. The first Rev of the Process Model Reports will start coming out this fall. The integrated site model at the very top here comes out the end of October. Is that date right? Why does it say 12?

SPEAKER: DOE approval date.

BROCOUM: DOE approval date. Okay. The other Process Model Reports will come out between April and late May of next year. Those analysis from those reports will support the TSPA-SR Rev.0 which will, in turn, support the site recommendation consideration report. As new information comes in that we're collecting this year and so on, those Rev.0 PMRs will be a updated to Rev.01. Rev.01 PMRs will support TSPA-SR Rev.01 which will support the SR. New information has come in as we improve the Process Model Reports. That will be updated to Rev.2. Rev.2 will support the TSPA that we eventually do for LA assuming the site is suitable which will support the LA. That's kind of the logic. This schedule, of course, depends on the funding situation. Lake has said we'll try to hold the schedule for SR under most budget scenarios. LA depending on the budget may have to be readjusted.

The system description documents define the design and there's a series of them that are being prepared for many or different systems of the design. They will provide and demonstrate compliance with what we call QL-1 which was safety issues that directly affect the public and QL-2 which are safety issues at minimal grade that indirectly affect the public.

So, this kind of summary slide, we're working on now and getting better. Culture of excellence where the big job in fiscal year 2000 is to prepare the final EIS and prepare the technical basis for the site recommendation consideration report. We're implementing EDA II. We're hoping to get the guidelines all straightened out during fiscal year 2000.

I talked about adequacy and there will be a lot more debate on that in the next two days. Rev.3 will be finalized after this meeting on its way, of course, eventually to becoming Rev.4. And, of course, in fiscal year 2001, right now we're planning to issue the final EIS and the site recommendation consideration report.

Thank you.

KNOPMAN: Thank you, Steve.

Questions from Board members?

COHON: On this very last slide--also, it came up on 18 --this point about adequacy information, this first point is a useful one and I know it's been said before it sort of crystallizes a key point. First, one statement about it and then a question for you. The observation is that first point about the impact of additional information is a useful, I guess, in being able to determine that even though, let's say, uncertainty is high on a particular parameter, if you believe that new information will not reduce that uncertainty, then you've still met this test. Now, I understand that the second point goes with the first. That is you still have to have a defensible safety case. But, there must be some kind of time dimension in this. That is given enough time, like infinite, you could know whatever you need to know about the mountain. So, there's some judgment that has to go into applying this first threshold. Have you talked through that yet, thought through the time issue here?

BROCOUM: Well, I'm not sure, you know, if perhaps given an infinite amount of time, we could understand the mountain, but we have spent, you know, like 15 years and close to $4 billion. So, I would say that we have probably spent quite a bit of money on this piece of real estate called Yucca Mountain. So, we've probably studied that more intensely than most other areas, you know, that have been studied in the world. So, I think there's been intense study at Yucca Mountain, you know, with all national labs and the M&O and the USGS. So, this has been an intense look at Yucca Mountain. Say, if we can't go into the site recommendation and say, you know, we think we've got a pretty good understanding and we think we know what's important and I think--and what's less important? If these important things change or go out in ranges that we're considering for, then, you know, they may make some changes. You know, if things radically change, I think we're not ready for a site--personally, we're not ready for site recommendation. That's where I am.

COHON: Yeah, I except that. I think that's a very useful way to proceed. I'm thinking about gray areas. Here's an example. Suppose you were told by one of the labs, you know, Steve, if we just had five more years, we could really give you a terrific model about corrosion rates of C-22. You've got to make the judgment, you know. How much more do I really get out of five more years of testing? I just wonder if you've talked through or thought through those kinds of gray areas?

BROCOUM: Well, in the last five years, probably somebody would say give me five more years and--scientists always ask more questions than answers. I mean, that's just the nature of science. At some point, you have to make decisions and that's what you're discussing. Is it a reasonable decision or what you make of the decision and move on. That's kind of what we're going to be talking for the next two days. There is no simple answer to that. I think, Lake said there wasn't a simple answer to that. I can't stand here and give you a simple answer to that. But, I think you'll hear collectively we're thinking through as we develop the repository strategy, we're trying to focus on what's really important. I know there's some controversy over that, but you'll hear, you know, the seven principal factors that people are focusing on. Those are the ones.

Some of the other factors, there's a lot of changes in the range. So, it doesn't make any difference to the result. We're trying to focus on what makes a difference, say, to the results on how the thing performs.

COHON: Good. And, I just want to make sure acknowledging that the program is going to be under tremendous pressure even more than it's under now one year from now that you don't decide that you've got all the information you need because it's September 2000 and not because of, you know--you see the point. Thank you.

BROCOUM: It's a big challenge to get to September or November of 2000. I acknowledge that right up front as being the one that's in the middle of trying to get that done.

KNOPMAN: Dan Bullen?

BULLEN: Actually, Steve, if you've got #21, if you can go back to that, the multi-colored one which we have seen before. I guess, the followon question is that if the PMRs are all going to be done by 04 of '00 and 05 of '00, I understand that the drafts of those have to be done even sooner. And so, the input or the time frame put for a new date is essentially either fast approaching or has come and gone. Could you talk about the ability to incorporate the new data that would tell you whether or not you have a fatal flaw in these PMRs or essentially is it what we see is what we get right now based on the data that we have in hand?

BROCOUM: Well, as new data keeps rolling in, you always compare it with what you had. You know, and if it reinforces what you know already, you can kind of rely. If it tells you something new you didn't know, then you've got to sit back and reconsider. I think we always plan to operate that way. This is a schedule. Schedules, you always have to plan out your work and so there's--you know, so if something was to come in right here between--let's say right here, just for an example, between Rev.0 and Rev.01, oh, you know, something outside that we were expecting, I think we have to go look at it. Okay? So, we've always done that. But, we have project management and we have schedules and assuming there's no big surprises, we go on. But, if there's a big surprise, now, we say, no, no, let's reconsider which I think is similar to what I said earlier.

BULLEN: I guess as a follow on to that, based on the fact that you're worried about budget limitations now, there may be no new data between Rev.0 and Rev.01?

BROCOUM: No, but a lot of testing will be going on and you will be--

BULLEN: Is that--I mean--

BROCOUM: --hearing about that from Jean and Mark Peters.

BULLEN: Okay. Great.

BROCOUM: So, exactly how that will be, I think they'll tell you.

BULLEN: All right.

KNOPMAN: Don Runnells?

RUNNELLS: Could we look at Slide 23, please? Could you expand, Steve, just a little bit on that last bullet. As you flew by it, you used the words "and get that all straightened out". I can't link that bullet into the schedule and into the logic diagram.

BROCOUM: Was it '96 we published a proposed rule for Yucca Mountain and the Department has been thinking about that ever since. And, I'm not sure. Lake made some comments on that in his talk. Okay? That rule is an interagency review. Can I say that because I said it already. Once that gets out of interagency review, it will be published as second proposed rule, Part 963, which is the Department of Energy's siting guidelines. Assuming that is finalized, we will use our new siting guidelines for evaluating Yucca Mountain for consideration for site recommendation. The current guidelines that are in place right now are 10 CFR 960. They've been in place since 1984. With the NRC coming out with a new proposed rule 10 CFR 63, with the EPA coming out just recently with their proposed rule that Ray Clark talked about, Part 197, the regulatory--you know, was kind of in flux, the regulatory infrastructure, if you want to call it that. So, we're trying to work through all of this and we're trying to project what we think the rules will be. So, we are working in a kind of not a very constrained environment right now in terms of regulations.

RUNNELLS: That helps. I know and understand what you meant by get it all straightened out.

BROCOUM: Yeah. But, the key regulations will be 197 from the EPA, 963 from the NRC, and 960/963 depending on how it all ends up from the DOE.

RUNNELLS: Okay, thank you.

BROCOUM: And, I'm looking at Lake here because I always have to be careful on the rules not public yet.

KNOPMAN: May the record show Lake put a thumbs up there.

BROCOUM: Okay.

KNOPMAN: Thank you, Steve.

I'd like to move on so that we make sure we do have time in the public comment period. Our next speaker is Abe Van Luik. He's going to give us an introduction to the repository safety strategy.

VAN LUIK: I want to talk about the repository safety strategy. It's basically going to be the subject for the rest of today. I want to introduce the subject so we can go to the first viewgraph.

The repository safety strategy and the postclosure safety case are not the same thing. The repository safety strategy is a plan to develop the postclosure safety case appropriate for each stage of decision making. It starts from the current postclosure safety case and adds to that an assessment of the current confidence in the safety case and the confidence needed for the next level of decision making.

The evolution of the repository safety case, we put out a Revision 1 which was based on the information from site characterization and looked at specific hypotheses to be tested in further characterization. We put out a Revision 2 which was based on the updated information available at the time and the VA system concept. It was the initial site-specific proposal for a safety case and identified 19 principal factors and the need to evaluate design enhancements. Now, we are working on Revision 3. It is in draft form. There are policy discussions going on within the DOE about its content and it should be done pretty soon, I would think, but it's based on the updated information from the VA experience and SR design enhancement. It updates the list of factors and the proposal for the safety case, focuses on seven principal factors and plans to simplify remaining factors where appropriate.

The strategy continues to develop under the postclosure safety case. I think I'm probably over-emphasizing that both the strategy and the safety case are living entities that, as soon as you learn something significant, you update them. Looking at current and needed confidence, we did that in Rev.2; we're continuing that in Rev.3. We are considering input, for example, from this body right here, regulators, stakeholders, public, on the adequacy of the safety case. Based on this assessment, it specifies plans to adjust the system concepts, the barriers to be relied on to obtain additional information and additional science--and by science, I also mean the engineering testing world--increasing the assessment capability, and modeling development. It has a discussion of prioritizing the remaining work, focusing on principal factors. What it does not do in Rev.3 and which it can't do is look at the impacts of budget. It just says here's your priorities and principal factors. To then go specifying what your work detail is going to be for the next year or two is a different call. You will not find that in the safety strategy. The updated safety case follows from a safety assessment after adjustments and new information. In other words, after you have done all this work, you still need to do a safety assessment before you can update it again.

This is a picture of what I just said. You have a safety case. You do a confidence assessment, look at your technical basis updated, go back and do a safety assessment, and then you update your safety case. This is like a bicycle wheel. We have a lot of questions about which comes first, the chicken or the egg. You know, do you do the safety assessment first, do you do the strategy first? Now that we are into this loop, this loop is revolving and it really makes no sense to historically try to point out what's going on.

We can go to the next viewgraph. The original of this--I think, it's instructive--said SR and LA, but really it could also say VA and SR design. SR design became a decision because in the confidence assessment that we did after we did the work for the VA, we said makes a very good case for 10,000 years, but the depth of confidence is not there where we are really comfortable with it and so this was like an intermediate step before the SR decision. So, we plan to continue this, and as soon as information determines the need for it, we will rev it again probably next year or in two years.

Confidence and long-term safety is a crucial issue for the site recommendation and the licensing decisions. It's not just that you have a number that looks good, but it's also that you can demonstrate that you have confidence that that number is meaningful. The postclosure safety case is the evidence to provide confidence sufficient for each stage of decision making. This is important, too. The VA was not the same as the LA; the SR is not the same as the LA. Repository decisions proceed as information is developed. Consequently, the safety case evolves. I've probably overstated that quite a few times, but it's an important concept. Based on the current status of the safety case, the strategy proposes needed adjustments to that case and prioritizes the work to get there. That's what Rev.3 is all about. That's why we're doing it.

What is the nature of the postclosure safety case? Some of you are familiar with a document from the OEC/CDA NEA and might recognize some of the sequence of thought here. But, before you can develop a safety case, you have to have some prerequisites. You have to have a system concept. You can't make a safety case that has no bearing on any system. And, you have to do an assessment of safety of that concept so you can see how it works. It includes a discussion of the status of the technical basis for the safety assessment, an evaluation of safety margins, a formal statement of the degree of confidence and a description of the approach to confidence for each aspect of that assessment. It provides feedback to future development to address remaining issues and is revisited whenever substantive new information is developed. This is the NEA's thought on the topic and this is exactly what we're trying to implement.

The original case in our particular application was in the site characterization plan. It's actually a very nice discussion of why we at that time thought Yucca Mountain would work as a repository. It was based on a preliminary assessment of the roles of the geologic and engineered barriers. It was the basis for the strategy for site characterization to design development at that time and model development. Now, the case has become more focused and has changed in some areas, but it is not a brand new totally radically different approach. As information has been acquired, design has evolved, and also as regulations have changed.

If we look at the safety case, a question that I get all the time is what's the difference between the safety case and the safety assessment? The total system performance assessment is the safety assessment. Well, the safety case is basically the body of evidence. It includes a TSPA. TSPA is a very important part of it, but also it discusses the design margin, the defense-in-depth. It discusses disruptive processes and events that may or may not be part of the safety case and discusses why they are or are not thought of as part of the safety assessment. This is getting tricky. It is discussed as insights from natural analogues that have bearing on the safety case and it discusses what you're still working on to provide further confirmation of your safety case. So, all of these things together are the total bag of things that you bring in to make a case for safety.

Now, when we get specific to the SR which is the next big ticket decision the DOE and all of society basically is going to make, TSPA-SR will address all factors potentially contributing to postclosure performance. It will perform sensitivity and uncertainty analyses. Design margin and defense-in-depth for the SR will be looked at through the enhanced design that you're quite familiar with and it will have an additional assessment of the contribution and significance of barriers. Disruptive processes and events, we will do qualitative assessments of key scenarios and we will do a quantitative inclusion of FEPs in the overall TSPA. Insights from natural analogues, in each Process Model Report, PMR that Steve mentioned, you will see a discussion of possible natural analogue insights and also natural analogue information that has actually been used in the context of developing the process model. And then, performance confirmation, we will have sufficient detail in the plan for SR to show what we are continuing to work on even as we make this decision at this point in time.

An example of what you will find in the strategy, Revision 2 of the strategy had the key attributes. The key attributes basically haven't changed any except that we have streamlined the wording a little bit. But, the strategy of the key attributes of it remain the same. It's what important in the implementation of it that have changed. And, here, we have a listing. It's a longer listing this time than it was last time partly because the new design introduces some new features that all become factors for enhancing system performance. However, key--you remember the 19 to seven that I mentioned in a previous viewgraph. Out of this list, there are seven that are considered key. I don't want to go into that now, but when the draft is approved by DOE, you will see a table in there that explains these and what the basis is for those decisions.

We said something a while ago that might have peaked your interest; assessing the safety case confidence at each stage of the decision making is an important aspect of the overall discussion of safety. At each stage of decision making--like, SR is a stage of decision making--we need to assess the robustness of the system concepts, whether it favors safety, whether it limits or mitigates uncertainty.

Assess the quality of the safety assessment. Does it explicitly account for uncertainty? Does it incorporate multiple lines of evidence? Assess the reliability of the performance assessment. Does it observe appropriate principals, criterias, and procedures? Have the models which are the basis for it at the process level been adequately validated? And, are the computational tools free from error?

How do we build confidence into safety case over time? Well, one good way is to look at multiple lines of evidence. Performance assessment indicates margins and importance of features, events, and processes, scenarios, and sources of uncertainty. Qualitative assessments including insights from natural analogues and identification of multiple diverse barriers. Alternative interpretations and opposing views; this has been handled very nicely, I think, in the EIS and we want to adopt the same approach in the SR and the LA. And, that is to acknowledge opposing views on certain issues, and to the extent that it makes sense to do so, do some analyses to show whether or not those views mean anything in terms of long-term safety. Accounting for phenomena relevant to safety. Another thing is that internal to the project we have a lot of alternative interpretations of our own data. We have alternative conceptual models. All of these are going to be discussed, and to some extent, incorporated into the analyses. And, we want to give some assurance that cases of significant consequence and uncertain likelihood can be dealt with. In other words, you have to show a capability that it's not extremely limited to only those things that you tend to find with the short-term testing that we're looking at.

We are going to continue development of the safety case. This is not the last word. The case will continue to be evaluated and presented throughout repository development. So, even after the license application is in, we will continually reevaluate it. As information about the sites increases and the focus on factors most important to postclosure performance changes, we will revisit it. Looking at the information for performance confirmation which goes right with the first bullet, if we make further changes in design, particularly those that would enhance performance, enhance robustness, thermal design, and performance--the thing that Lake Barrett talked about this morning, if after 25 or 30 years of testing we decide that the issue is more important than we thought or less important than we thought, we will change the safety case and the safety strategy will be changed. And, if regulations and standards in the future would change, we would also revisit this whole arena. So, the repository safety strategy, you can expect to see updates to as soon as important information in any of these categories comes up.

That's my introduction, basically, to what other people are going to be referring to which is the implementation of the repository safety strategy and the continued testing and then the performance assessment arenas.

KNOPMAN: Thank you, Abe.

Questions from the Board? Paul Craig?

CRAIG: You did make reference on Page 10 and some other places to the concept of defense-in-depth which, as you know, is very important to the Board. We refer to that rather frequently. To what extent are you going to explore the expansion of the one-off concept? We're concerned about the relative role of the engineered barriers versus the mountain. It would be very useful to be able to split those apart and discuss exactly how the mountain performs all by itself and how much the engineered barriers contribute. Can you analyze that for us?

VAN LUIK: In fact, one of the internal discussions we're having on RRS Rev.3 is that it does contain one approach to that type of analysis. Part of the internal discussion we're having is that in order to do that analysis, you do them to gain insights and that's the only reason you do them because you're evaluating scenarios that cannot possibly happen. Their likelihood is zero. So, we have them in there right now. We show that the mountain has a role about eight orders of magnitude reduction in potential dose from the mountain itself. But, the reason that you create a system is because you're not relying totally on that. You also have to take care of a couple of other orders of magnitude and that's why you invoke an engineered system.

So, one of the internal discussions is is the current approach to showing that--there's no quarrel with needing to do it, but is a current approach to showing that the right approach or should we go to a more probabilistic approach that stays within the bounds of what we think the expected roles of these things would be. So, there is discussion on that. In the draft that we currently have, there is an example of calculations set and we will determine very quickly whether we stay with that or go with a different approach before we issue this version. But, we're committed to do that, yes.

KNOPMAN: Dan Bullen.

VAN LUIK: Should have just yes, I guess.

BULLEN: Actually, right here on the same viewgraph where you talk about performance confirmation, do you see the postclosure safety case as driving performance confirmation or do you think that performance confirmation will make significant changes to the safety case?

VAN LUIK: It's a revolving wheel, yeah.

BULLEN: But, the followon question here is that if your performance confirmation doesn't test a more aggressive environment, then you won't have any reason to update your safety case. Is that not correct?

VAN LUIK: This is a discussion we've had internally that you drive performance confirmation through the strategy, through the needs of the safety case. At the same time, if you only--and this is why I don't like the word performance confirmation. If you only do those tests that you know will confirm what you've already found, then it's a self-fulfilling process and you're wasting everybody's money and time. So, performance confirmation has to honestly look at those issues where we still need more information to close the uncertainty gap and there is the possibility that we will have surprises, although we are not planning to aggressively look for surprises in some areas. But, it's a balancing act.

BULLEN: But, by aggressively looking, if you don't find the surprises, then you're a little bit more convinced that the repository safety case that you're building is robust enough to meet the needs of post-closure time.

VAN LUIK: Yeah.

BULLEN: And so, that's why I asked about aggressive testing as opposed to just performance confirmation.

VAN LUIK: Oh, that's what you meant by aggressive?

BULLEN: Yes. I mean aggressive so that you can--if you want to relax the temperature limits, for example, or you're going to have a hot drift. I mean, that's sort of the issue that you want to take a look at.

VAN LUIK: Or do you install some kind of a testing mechanism to test pieces of the hot drift?

BULLEN: Right. Maybe, that hot drift may not perform as you're expecting. So, you have to abandon that drift and put it somewhere else because it has to stay cooler, but that's why I'm interested in an iterative process of the safety case because if you want to look at performance confirmation--I mean, in estimates, if you ventilate for 50 years, there won't be anything to worry about because there won't be any surprises. If you're going to try and take an aggressive stance and you want to say, well, we really can't close at 50 years, you have to have the data to support that. That real data should be data from the repository that says, yeah, the performance is as expected and so we think that our projections are correct. But, if you don't have the aggressive environment, you won't be able to make that case.

VAN LUIK: Yeah. And, Lake made the commitment this morning that during that 50 year period, we will do the testing that will give us a definitive word on whether or not we close off at that point or go further. But, the reason I was a little cautious about the aggressiveness is because we don't want to do things that we intuitively know are not going to lead anywhere.

COHON: Abe, will one of your colleagues be addressing in a later presentation how the seven factors were chosen from the list of 27?

VAN LUIK: That is not in the presentations that we were going to make this time. In fact, that's part of what the internal dialogue over the content of this report is still about is the--basically of that going from 19 to seven. But, we will be looking at some of the consequences of that in the planned testing and the plan analysis work. We were just simply not planning to go into that, although once the document is out in public, it certainly will be there in some detail.

COHON: Can you say just a few words about the process--I mean, the considerations that go into the choosing of the seven?

VAN LUIK: Yeah. The considerations I went into were multi-staged. I ran a little pilot program myself first using DOE and contractor staff to quickly run through what would be involved in reassessing all the aspects of the safety case and came out with a reprioritization list. We then handed the whole thing to the M&O and said now we have shown you one way to do it; now do it right. They brought in all aspects of the project in some detail, went through and reevaluated all of the things that were done for RSS 2 and not only the physical new things brought on by the design, but also the implications for processes, and then came up with a list of something like 52 and have gone from 19 to 52. Then, in further discussions, brought that back down to the list I showed a while ago. I think it's down to 27 or 32 or something, and then by basically talking through some kind of consensus as to which one feeds which and which one is a direct link to performance assessment and which one in sensitivity studies that were done for LADS 2, for example, were shown to be key, then came down to that seven.

So, that was kind of the process, but I'm not prepared to go into the nuances of the discussion. There were, I mean, days and days of large meetings and discussions on these things which were captured, I think, pretty well in the notes that are actually in the archives on this decision making process.

COHON: Thank you.

KNOPMAN: Dick Parizek?

PARIZEK: Viewgraph 12 is obviously a list of things that need to be done and you said that there will be analogues used to help support the understanding of all of those process models. On Viewgraph 10, you say, well, insights from natural analogues obviously is important to this process. Then, we go on to Steve Brocoum's Slide 9 and he has natural analogue studies at Pena Blanca as the planned testing as the only analogue mentioned for which testing is to be done. Now, that implies that all of the analogue studies are done and are mature and can be used to support your process models. I see a disconnect here because I think there's quite a few analogues that may not have been investigated that could have been on that investigation list. So, what happened to the other analogues?

VAN LUIK: Okay. We internally put together a natural analogue team. That team pulled together work that had been done by others and in the literature on multiplicity of analogues. That work is being basically farmed out and discussed with the process level modelers. So, there is some information, for example, from Oklo, from Cigar Lakes, and from other analogue sites which are not quite mimicking Yucca Mountain processes, but get insights on those processes and you will hear tomorrow from Bo Bodvarsson and from Joe Farmer from Livermore on their particular process models and what natural analogues they have used not only to sharpen their intuition, but also to kind of guide where they're going. So, what you saw in these two talks is not the only thing to the story.

Now, the reality of it is that we had a plan laid out with natural analogue work that we would like to do. The funding realities for next year are restraining us to only do something on Pena Blanca next year. The rest of it will go into the PC plan and will become part of performance confirmation. So, the story is not over, but it's not like we are making broad statements about natural analogues that would only do in one. We've actually done a pretty good survey, I think, of the excellent literature on the international work on natural analogues and seen where it applies to the different models that we're using. So, there's a little bit more to it, but it's not a full-blown international search for natural analogues at this point either. So, it's somewhere in between.

KNOPMAN: Thank you, Abe.

I have a question. It seemed to me on your Slide 11 when you talk about TSPA-SR and then design margin, defense-in-depth, the disruptive processes, etcetera, that there is a certain self-referencing quality here to TSPA.

VAN LUIK: Uh-huh.

KNOPMAN: So that these are not multiple independent lines of evidence. Everything is getting stacked up in terms of their significance as it gets crunched through TSPA. How do you test TSPA with these various other--with insights from these other sources if you keep going back to the same models as your basis for evaluating their significance?

VAN LUIK: There is kind of an inbreeding and it's partly the presenter's fault because my focus is TSPA. But, TSPA is the place where we integrate all that is important out of these other things. The reason I mentioned features, events, and processes in a quantitative evaluation of the FEPs, you know, in a systematic way to create scenarios and to find out what's important in your system separately from TSPA is because part of the reason of doing the features, events, and processes process is to exclude some things from TSPA as not contributing to performance. So, that's why I mentioned it separately here. Those that are excluded will become still part of the safety case because you discuss what the basis is for the exclusion. But, only those that are included will then roll up into the TSPA. So, the safety case will be also a discussion of what is not in TSPA and why it isn't.

Design margin, defense-in-depth, of course, the design is going to be rolled up into TSPA. It's part of the system and it's a system performance assessment. But, we will look at the contributions and significance of individual barriers in separate calculations also in TSPA sensitivity studies, but also in separate calculations of the type that I was hedging with Paul on which is, you know, we have done it one way, so far. There may be other ways to do it. But, those will be separate analyses reported in the safety case, but not particularly part of TSPA.

KNOPMAN: Okay. That's a longer discussion we can have at another time. Leon Reiter?

REITER: Abe, if this will be answered later on, that's fine. But, does the safety strategy and/or the safety case plan to address and evaluate post-10,000 year behavior, and if so, how?

VAN LUIK: We were just having a discussion on this this morning. The idea behind a license application is to show that you comply with the regulation that applies which would be Part 63. Both it and 197 say that you will do a 10,000 year quantitative calculation. The safety strategy for the SR and LA may or may not be limited to 10,000 years. My idea this morning was that it would be limited to 10,000 years because it's addressing 960 and 963 which refers right back to 63 and 197. The discussion we had this morning with Steve Brocoum was, you know, there may be valid reasons for showing something beyond that. So, we had not decided on that.

Steve will answer.

BROCOUM: You know, when you have a regulation and you have certain legal requirements so you have a legal hat or a technical hat on, you'll meet with the lawyers. And, of course, what they want you to do is put as little as possible to make your case and not do anything that can get you in trouble. But, to get the insight for the 10,000 years, you know, and how it's going to perform, we always felt we had to do the calculations out beyond 10,000 years. In fact, our current draft of our repository safety strategy does talk about doing analyses out beyond 10,000 years.

So, I don't see any difference and I don't foresee any difference in the way we do it in the future than what we've done in the past for doing the calculations. But, we put it in a license application and it may be dictated in some part by, you know, the legal advice, not what we present in our--we'll always have the analyses that will go out as they've gone in the past in my view.

VAN LUIK: So, the issue is where do you put these analyses? Do you put them in the documents addressing the regulation or do you put an additional document out with these other analyses that give insight? I don't know. So, it's a policy call waiting to be made.

KNOPMAN: Okay. Thank you, Abe.

VAN LUIK: Thank you.

COHON: And, thank you, Debra. We'll turn now to the public comment portion of our agenda. Before I call on the one member of the public who has signed up, I note that Captain Clark is still with us and I want to express our appreciation for that. He indicated to us that he has a reminder of the fact that he is a member of the Public Health Service and not just on detailed EPA and is on call because of Hurricane Floyd and, I gather, will have to go muster for their purpose soon. So, we especially appreciate your willingness to stay, Captain Clark. I would like to continue the questioning of Captain Clark and EPA with my own question and we'll see if anybody else wants to chime in and then we'll move to you, Judy.

I have a question. It's sort of an all-embracing one, but it touches on several points that you made, Captain Clark. It has to do with how the EPA standard anticipates or EPA anticipates that uncertainty will be a concern in the application of the standard or standards. You didn't mention, but we know that with regard to the 15 millirem standard, I believe, the proposed rule is that the mean or the median performance, whichever is higher, is to be used. That's one observation.

And then, in your presentation--no one else has to refer to this. I just want to give you a couple of things to react to. In talking about reasonable expectation, you made the point that it takes into account inherently greater uncertainty of long-term projects. You made the point that EPA expects reasonable bounds to be considered and later on you make the point that--here's a quote, that it will include a full range of reasonable parameter value distributions. I have not read the standard. So, all I have to go on is your presentation and the summary that I've seen elsewhere. Other than the mean median thing, is there any part of the rule that requires DOE or NRC to use values other than those two things? That is some specific way in which bounding is to be used or the full range of parameter values as you say here?

CLARK: I think the only factors that we specified are those that are referred to in the groundwater standards of the two liters per day in the Lathrop Wells location. Other than that, it's essentially up to the implementing agency which is NRC in this case.

COHON: Okay. Thank you.

CLARK: Uh-huh.

COHON: Are there other questions for Captain Clark?

(No response.)

COHON: Judy, will your comments be--do you have any questions directed to Captain Clark? If not, we can release him from this captivity. Okay. Thank you very much, Captain Clark. We appreciate your willingness to stay later.

CLARK: Certainly, and I'm sorry if I caused confusion earlier when I hesitated on my answer.

COHON: I understand. I now call on Judy Treichel who asked to be heard.

TREICHEL: Was this an effort to make Hurricane Floyd more attractive to Ray?

COHON: We may have.

TREICHEL: I have two things and one of them is something that you've heard for years and years and years. It's my problem with the word "stakeholder" and it was used twice today; on one slide that Abe had on Page 4 and on Steve Brocoum's Page 13. It's very obvious and it was made obvious to me years ago that stakeholder means the nuclear industry and people argue about that and call me a valuable stakeholder, but I refuse to accept that title. And, the fact that it's used in the way that it is, I think is important because the word "reasonable" gets thrown around and has been thrown around a lot today. Our question has always been reasonable to who? And, I think it's reasonable to the stakeholder, to the nuclear industry, when we're talking--in the way that we use that word.

Where I'm going with this is the safety strategy used to be--or the repository safety strategy used to be waste isolation and containment. That was very easy to understand. But, now, we've moved--because Yucca Mountain does not contain and does not isolate waste, we've moved into this safety strategy which is real sort of hazy. As Abe was talking about in his presentation, there's this evolving or changing or the safety case needs to change. And, if Yucca Mountain was isolating and containing waste, safety strategy wouldn't be changing. It would be safe and you wouldn't have a standard that had to meet a test of reasonableness.

And, as Lake was--when he got up and commented that if you didn't have a reasonable standard that you might rule a repository in any fresh water environment which I guess makes a distinction between WIPP and Yucca Mountain. And, I don't think that's terribly important. You might, in fact, rule this one out and you don't always have the sort of red herring that gets thrown in where you have the choice and the EIS does this, too, and I certainly will be commenting on it where you get a choice between having Yucca Mountain or having just an abandoned batch of waste everywhere and that's not the case. You don't have to do one or the other. And, Yucca Mountain isn't the only thing that saves you from having abandoned wastes in all kinds of places in the country. I think reasonable people would understand that.

And, now, we're down as cruel as reasonably acceptable. I won't even talk about that. That's ridiculous.

And, we have the reasonably maximally exposed individual and I don't have any battle with that. I'm very glad that EPA came down in the way that they did that, but this person has to be protected; not reasonably protected, but just plain protected. And, if Yucca Mountain doesn't do that, then we don't need Yucca Mountain or we're certainly not ready for it and that comes into these discussions that were with Steve Brocoum about, you know, supposing in five years, you could find out something important? Well, there's been $4 billion in 15 years. Some people would argue that for many of those years, they were doing the wrong work. Perhaps, not doing it wrong, but doing the wrong work.

So, I don't know that you can put a line in the sand and that's the sort of thing that has the public, at least in Nevada and I'm quite sure in other places, too, very nervous about this project and the kind of wordsmithing that goes on.

Thanks.

COHON: Thank you. Does anybody wish to respond to that or pick up on any of Judy's comments?

(No response.)

COHON: I would like to just elaborate on one point you made, Judy. This issue of reasonable expectation or reasonable assurance, in this case reasonable expectation, is really something that can't be avoided. You need something like that and that's because of uncertainty. We cannot know and no one can say exactly how this repository or any other repository will behave.

So, it's unavoidable that one has to deal with probability and uncertainty. And, what we need is some measure of that or some guidance on it. What we've gotten from EPA is reasonable expectation as we just heard from Captain Clark. The interpretation of that is up to--I'm putting words in his mouth--the NRC. Your point about reasonable expectation to whom is well-taken, but it's unavoidable.

Any other comments or questions from anybody? Yes?

KESSLER: John Kessler, EPRI. It's along the same lines of the difference between reasonable expectation and reasonable assurance and I think this--and I'm going to ask a question in the form of a comment if Ray would like to respond.

Looking to the preamble to the Part 197 standard about what reasonable expectation says and Ray hinted on it again this morning is that you have to look at all the components of the system even if they're highly uncertain and build those into your safety case as opposed to looking at a bounding analysis where you may throw out components of performance because you don't know them well.

One example might be cladding. There's been discussion about should cladding be part of the safety strategy or not? The way I read what EPA has just said about reasonable expectation is you put it in. Now, if that's going to be a part of SR and then DOE reserves the right to not have it when it comes to LA, that's fine. Certainly, for SR, it would be nice to put in everything that they believe has some bearing on a safety case.

So, I guess the first question for Ray is is that what he means or is that what EPA means when they mean reasonable expectation; is did they expect to see DOE put everything into their safety case that they bring before NRC? That certainly would have some big implications in terms of safety strategy and prioritization and everything else.

COHON: Would EPA like to respond to that question?

CLARK: I think, basically, John's right. Now, whether everything really means everything, that's probably debatable. I'd certainly have to consult with NRC, I believe. But, all these reasonable factors, there's some basis for.

I'll ask Ken Czyscinski then to address that, as well, if I may?

CZYSCINSKI: It's basically the applicant's obligation to present the safety case and what they choose to put in or leave out is up to them. They have to defend it in this licensing forum. What we're saying by reasonable expectation is not to a priori eliminate things that may have beneficial performance effects simply because you can't quantify them to high degrees of certainty.

For example, if we look at the analysis in the VA, you see the DOE assumed in the assessments that every drop of water that seeps into the emplacement drift contacts the can. This is a very conservative assumption since the width of the can is only about a third of the width of the drift. We don't consider that a reasonable expectation kind of assumption. In addition, they assume that every drop of water that contacts the can is uniformly distributed over the can. Again, this is not a realistic assessment. What will drip on the can will also drip off the can. So, looking at those assessments from a reasonable expectation perspective, we think they're extremely conservative. So, that's the kind of assessment we would advocate as an interpretation of reasonable expectation.

COHON: Thank you. Any other questions or comments?

(No response.)

COHON: Seeing none, we will now take a break until 1:00 o'clock. Let the record show we're getting eight minutes more than originally scheduled for lunch. We will remember that in the future when we have to take them back.

(Whereupon, a luncheon recess was taken.)

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

KNOPMAN: Okay. This afternoon's session continues our discussion of the repository safety strategy. Our first speaker is Mike Voegele who is Deputy for Regulatory and Licensing and is with Science Applications International.

VOEGELE: What I'm going to talk about this afternoon are the activities that are going on within the program right now of how we're going to implement the strategy to complete the safety case for the site recommendation. We've been following the plan that's in Volume 4 of the Viability Assessment which correlates to repository safety strategy Rev.2 for developing our safety case.

The implementation that we're doing started from the 19 principal factors that were the viability systems concept that were in the viability assessment. Right now, what we're doing is evaluating data that we've received since the viability assessment and enhancements that we've undertaken to the design since the viability assessment. We've set out a path to update the set of factors that were in the viability assessment. We used a couple of techniques and a lot of information to do this. What this bullet says is that we used preliminary--for proposed assessment calculation and barriers importance assessment to identify principal factors. As we step through this, you will see there's a fair bit more involved. We certainly used the information that was available from the past several performance assessments, but we also used the knowledge that was resident in the principal investigators who were doing the work on the program, the people who were doing the performance assessment calculations, the designers, as well. What our goal was was to try to prioritize the work to complete the safety case for the site recommendation.

The design enhancements that I'm talking about were changes to the viability assessment design. We adopted a more robust waste package. We're looking at including a redundant drip shield to provide defense-in-depth. We're looking at backfill to protect the waste package and the drip shield. We're looking at what we're categorizing as an improved thermal design.

This next viewgraph just gives you an example of concepts of defense-in-depth to water diversion. One of more of these may be effective and we'll try to decide that and use it in the site recommendation documents, as well. First of all, there's a possibility of diversion of this infiltration by capillary barrier within the rock system itself. There's a possibility of diversion by the drip shield and there's a third possibility of diversion of the water by the waste package. Just as an example, there are at least three different mechanisms identified there where water could be diverted. So, that's a simple concept of a defense-in-depth type concept.

We mentioned that we were updating the factors for the nominal scenario. This is the list of principal factors that were in the viability assessment that correlate to that design. We've augmented that list and generally what the augmentation consists of is to address new design enhancements. So, you'll see that we have a little bit of change down here in the engineering components, as well, and addressing new data components. So, they're focusing a little bit in this particular table details of what might have been a single item in the VA. A set of principal factors might be uncoupled a little bit here to allow us to look in more detail at components of those principal factors.

As I mentioned, our goal was to prioritize these factors, to use them as a driver for the work that we believe needs to be completed for the site recommendation. It was really conducted around not just the barrier importance analysis, not just the information that we had in total system performance assessment, but we used the scientists, engineers, the PA staff, the regulatory staff on the program who have in their minds and who have through their research looked at what the important things are in terms of determining the performance of a repository at Yucca Mountain. We started from the preliminary TSPA. We used the variability assessment and performance assessment calculations. We used information that had been gathered from previous performance assessment calculations and, you know, we were talking just a little while ago how I would characterize this. It certainly was a total system performance assessment and base calculation that was looking at enhancements over and above the VA. It is not something at the level that Bob Andrews is talking about having done to support the site recommendation. So, you know, it's maybe TSPA-VA, one and a quarter or maybe one and a half. It's certainly not where this thing has to be as opposes the performance assessment. If I used the word "TSPA" to describe any of the curves I'm going to show you this afternoon, please correct me because they are not that. They are not compliance evaluations. They are not equivalent to what a TSPA has to be. They were calculations that we used to inform ourselves on what might be important to performance.

KNOPMAN: Mike, excuse me. Could you adjust your microphone because your voice is coming in and out and I'm having a little trouble hearing.

VOEGELE: Okay. Where would you like it?

KNOPMAN: Just get it more in the middle.

VOEGELE: More in the middle. Better? You want it up, he wants it down.

KNOPMAN: Up, no--every time you turn your head--

VOEGELE: I understand. Yes, no? It's going to get you again every time I turn my head. Okay. I'll just talk louder and let you pick it up from down on the lapel. Is that better?

SPEAKER: Yeah.

VOEGELE: Okay. The most important thing that the scientists, engineers, and PA staff contributed to our prioritization of the factors was their knowledge of model uncertainties and the limitations that existed in the preliminary analysis that we were using. I hope that I can make that clear to this group that it was not simply the barrier importance analyses, it was not simply the results of total system performance assessment that we used to look at priorities and those factors. Probably more important were the principal investigators' knowledge of the model uncertainties and the limitations of preliminary analyses.

Abe Van Luik this morning emphasized this is an ongoing process, that we expect to do more with this, and we have already identified from working with the principal investigators areas that we need to look into this more carefully before we complete the performance assessment for site recommendation.

We tried to assess our understanding of what the current confidence is in the data and what would be needed to determine the factors needed for an adequate safety case. Our objective was to focus our work on the most important factors and the adequacy of information from the safety case for site recommendation and license application. So, again, this is not a compliance type performance assessment calculation. It is an evaluation that was done to inform ourselves on what were the important factors.

This is an example of one of the types of analyses that we did to look at the enhanced design, the design that followed the viability assessment. There are about three or four things that are illustrated on this charge. One of the most important ones is if you just look at no barriers at all, solubility limited to releases, the natural barriers themselves are effective in reducing the estimated dose rates by eight orders of magnitude. The remaining dose rate is due to a relatively small number of radionuclides less than .004

percent of the total by dose, by mass, by curie content, whatever you want to do. The less then takes care of that. So, it's a very small amount of the remaining material that's not taken care of by the natural system in this analysis. I will emphasize you will probably hear things in both Bo Bodvarsson's presentation tomorrow afternoon which are things that will eventually get into performance assessment calculations that would have changed these results. These are relatively conservative. They're nominal case. They look more like the VA than I believe the PAs that will be done for site recommendation will look.

In this analysis, we used a waste package and a drip shield to address that residual. And, as you can see, looking at the releases in this analysis from the natural barriers only, this is the natural barriers release. If you have natural barriers waste package and drip shield, you have no releases for 100,000 years. And, if you have just the natural barriers and the waste package, take the drip shield out, this is what the release might look like. That gives you an indication as to the importance of the engineered components in this analysis.

So, let me talk a little bit about this barriers importance assessment that we used. It's a technique where we took the performance contribution of a component of the system completely out of the system. So, this is not a probabilistic distribution of the performance of these components. We totally cut the performance of components one at a time out of the system to see how that affected the performance. So, this is a specialized sensitivity study in which the effect is omitted from the calculation to determine its importance of that calculation. They are not expected performance calculations. We only did them to get some insight as to what the importance was. We looked at additional insight. We looked at the nominal performance case. We also looked at the unanticipated early failure of a waste package to gain additional insight.

Okay. This is one where we call this a preliminary barriers importance assessment. The base case in this nominal case gave zero release for 100,000 years. Individual neutralizations of all but two of the barriers also gave zero release. That is the beginning of an indication that either the barriers are unimportant to the total performance or they are backed up by other barriers. That's about all you can judge from that calculation. If that is true, if a barrier is unimportant to performance, the eventual compliance demonstration may not be sensitive to unresolved issues from the barrier. That was what we were seeking. We were trying to understand how well we could develop an argument that would, say, for instance, that if you are placing reliance on six or seven or eight of these barriers, the other nine, 10, 20, whatever your total number turns out to be how you package them, may not be as important in your compliance determination eventually. And, I'll emphasize it again. What this tool was was an investigation to let us gain some preliminary insight into how that might work.

Individually, only the waste package and the drip shield neutralizations gave any contribution for 100,000 years. Now, within this particular evaluation when you do the waste package neutralization which is this blue curve, you have diffusion controlling up until the point of about 10,000 years and that represents in this evaluation the failure of the first drip shield. So, that's why you get a peak in this particular curve at that point in time. So, you're looking at diffusive releases down here and then when the drip shield fails, remembering that you've got the waste package containment neutralized, this is what happens. If you do it the other way around, if you neutralize the drip shield, this is the type of performance you get. It's a strong performance in the nominal case of the waste package. So, in the waste package neutralization, that 10,000 year number is a result of the failure of the first drip shield.

Again, I want to emphasize this. This is not expected performance, but this suggests that uncertainties in the waste package performance are important. I think that is something that you would have concluded for yourself in looking at the sensitivity studies and all of our previous performance assessment calculations. We just look at it again from this perspective.

We repeated these analyses for a juvenile waste package failure scenario. This was one to try to understand again and give a different perspective on it if we have a failing waste package. Again, we looked at neutralizations of the natural barriers up in here. We looked at the saturated zone and the unsaturated zone. The overlying rock is the unsaturated zone above the repository horizon compared to the base case. And, you can see not very much difference other than for the saturated zone. If you look at the neutralization of the engineered barriers, they're a little bit more difficult to sort out. The colors will help. The waste package again is blue, the cladding is this maroon/purple color, the drift invert is this green color, base case, and the red should be the drip shield as before.

When you look at that information, the base case, it releases at about 10,000 years which is again when the drip shield failed in this particular evaluation. No other releases occurred for 100,000 years. When you look at neutralizing each natural barrier, you get minor changes from the base case because the barriers are relatively redundant with each other. We're going to look at a case where we looked at all the barriers together on another slide to help give us some more insight, but generally the barriers in this situation are redundant with each other. There's very little difference. Neutralizing the engineered barriers; the waste package neutralization gave the largest change, cladding was less important, and the other changes we categorized as relatively minor. So, here is the base case, this dark colored line. The waste package gives the biggest change when you take it out of the system and then the cladding is the next highest one. But, relative to orders of magnitude of change, the waste package is the more important one in this analysis.

Okay. In this one, we looked at the natural barriers more as a combination to provide retardation capability. In the nominal case, they contributed very little because the radionuclides remained in the waste package. After the waste package fails, they're very important. Under all conditions we looked at, retardation was very important and solubility was less important, but again it, especially in the longer time frames, has a significant contribution, a couple orders of magnitude.

Okay. So, what we did in these prioritization workshops, the gathering together of a lot of the project scientists to look at this information, we looked at our assessments of current confidence, what we knew about the information related to those models, what we might need to enhance confidence in those models, and we made a working conclusion that the analyses that we had done suggested that there's probably a high likelihood of adequate margin, but they relied very heavily on the waste package and the drip shield. This working group also concluded that that confidence probably would not be adequate for the site recommendation unless the natural systems could be demonstrated to contribute significantly, as well. So, in addition to the engineering components that looked to be important, seepage, retardation, and dilution were also concluded from the results of these workshops to be important factors.

Now, Abe told you this morning that he wasn't prepared to talk about the seven principal factors. I have them on a slide here, but I would like to just caution you that this is work-in-progress. The document has not been reviewed by the Department of Energy and this is subject to change. Basically, what I have told you--remember, let me emphasize again it was our previous knowledge of sensitivity studies done in the performance assessment calculations that have been done and was the barrier importance evaluations that we did to support this with the enhanced design features incorporated in them at some level. It was the understanding of the principal investigators about needed confidence and weaknesses in the models where there was need for improvement that led us to conclude that seepage into the drifts, the solubility limits of dissolved radionuclides, dilution of the radionuclide concentrations, retardation of radionuclide migration in the UZ, SZ, performance of the waste package barriers, and the performance of the drip shield appeared to contribute more to repository performance than what I've called the other factors down here.

I think I would like to leave it at that. This is --it's work-in-progress. I will again state probably to the point of having to beg your forgiveness for having said this too many times, this is not performance assessment. This is a calculation that we did to try to peel apart some of the onion layers to understand what were the big contributors to performance at our site.

Okay. We are in the process of using those factors to prioritize our remaining technical work. So, the testing analyses are focusing primarily on principal factors and sensitivity studies to examine potential simplifications in the non-principal factors. What we're talking about there is downstream, long-term, going into a license application environment, trying to build the simplest, clearest, most defensible argument that we can to convince our regulator that we have adequate margin to meet his standard, that is typically done by simplifications to a large number of components in the system and focusing on what I've called the principal factors here. I believe we have a fair amount of work to get done before we get to there and I think you're going to hear Bob Andrews tell you a little bit more about how we will be dealing with this in the context of the site recommendation.

We are also addressing what we have identified as opportunities for enhanced performance; the seepage threshold, cladding performance, and the canister performance. In the viability assessment, we had a carbon steel and a stainless steel. In this new design, we have two stainless steels and there's a question about whether you should try to take credit for the corrosion performance of both of those stainless steels. Because of the similarity in mechanism, it may be hard to argue that one of them is providing defense-in-depth of the other one. So, that's an additional issue that we have to address. The work scope that we've developed is reflected in the plans for the

Process Model Reports and the associated analysis and model reports.

We have a fair amount of work to do. I had mentioned that workshops that develop the prioritization tables that I just showed you still have some unresolved questions that we are working. I think that Abe showed you a chart this morning and Steve made a comment that we would have another rev to this repository safety strategy out by next spring. I think that's very real. I think we need to do that. We'll have new information supporting the performance assessments. We'll have better information on the design. We'll have better calculations upon which to look at this. We also have to look at our completion of the screening for the features, events, and processes that are important to repository performance to confirm the identification of principal factors. We have to complete our model development for these principal factors and analyses to support the simplification of the non-principal factors. We need to address how we're going to incorporate parameter and model uncertainty into the total system performance assessment. We have to complete our representation of the disruptive events. Those of you who were looking at that table as I flashed it up there briefly will notice it did not have the disruptive events on it. We have to complete our performance confirmation plan to understand how those pieces fold in.

We have things to do beyond that, as well. We are going to update the strategy after we do the additional analysis for the site recommendation effort, to incorporate those parameter and model uncertainties that are identified, and additionally to incorporate the results of the screening of the features, events, and processes. We need to finalize the principal factors for the SR safety case so that we can clearly articulate exactly how we're going to develop the safety case that Abe talked about this morning. We would like to finalize the areas for simplification that would be appropriate for our license application safety case. There's a possibility that as the design evolves, as our performance confirmation strategies evolve that that could also have an effect on how we develop our safety strategy.

So, with that, I will take your questions.

KNOPMAN: Thank you.

Dan Bullen?

BULLEN: I'm a little bit perplexed by the presentation because if you take a look at your Slide #10 and you look at the neutralization of the engineered barriers, you'll see that the spent nuclear fuel cladding seems to have a significant impact and yet you say that it's the neutralization of the waste package in the drip shield that has the most significant effect on the long-term safety case. Could you tell us how you dealt with cladding? Is there cladding credit taken for all the analysis that includes the neutralization of each of the barriers or--

VOEGELE: Yes. Yes.

BULLEN: Okay. So, there's cladding credit throughout the whole thing?

VOEGELE: There would be cladding credit throughout the whole thing, right.

BULLEN: Okay. So, did you do the analysis that said we neutralized cladding in addition to everything else or is cladding always going to be there to--

VOEGELE: What you're looking at here are individual neutralizations of the barriers. We haven't done a lot of the coupled ones or we would take the waste package and the cladding on, for example.

BULLEN: Right. But, I guess the question that I have for you is that in the previous slide you said that--which is #9--that waste package neutralization--well, let's see, only waste package and drip shield neutralizations give any contributions for 100,000 years.

VOEGELE: Yes.

BULLEN: That means that if you essentially neutralize everything except the drip shield and that you also neutralize cladding? Does that give you a release?

VOEGELE: These are--

BULLEN: I mean, these are just everything but, right?

VOEGELE: Yeah, these are individual ones. You're going to ask me to speculate in which case I'd probably ask Bob Andrews to--

BULLEN: Well, I was just going to ask Bob this. In this case is there cladding credit or not?

ANDREWS: In these cases, there are cladding credit, yes.

BULLEN: Okay.

ANDREWS: These are individual neutralizations.

BULLEN: Okay. Thank you.

KNOPMAN: Dick Parizek?

PARIZEK: On the list of Page 13 of other factors, colloid migration was included as another factor. What's the basis for that dropping out as not being that important? Is it something new in the program or, say, Calico Hills experiments that show that?

VOEGELE: I'm going to be able to answer that from my perspective in the meetings and that was not--that was discussed in the meetings, but it was never demonstrated in these analyses that it had a significant contribution to performance.

PARIZEK: I didn't know whether the experiments had gotten far enough along to be able to say that you can't get colloids from here to there.

VOEGELE: I guess, I could ask Bob or Bo if they'd care to comment on that?

ANDREWS: The colloids were incorporated in this model with the same assumptions used in the VA. Those colloid models are being revised based on new information both laboratory and NTS specific information that the folks at LANL are collecting and interpreting and revising the models, essentially. So, those revised models will be incorporated in the SR. They're not reflected in this particular set of analyses, though.

PARIZEK: Thank you.

KNOPMAN: Alberto?

SAGÜÉS: Yes. Do I understand from the examples that you gave that drip shields should only be "needed" in case of waste package juvenile failures? Like, if there were no waste package juvenile failures nothing would be happening for like, say, 70,000 years or so?

VOEGELE: That's a correct conclusion from these analyses. I don't think I'm prepared to say that that is defensible in either of the two arenas that we have facing us.

SAGÜÉS: I see. I see. Is there any way of quantifying in all these analyses the fact that, you know, we're talking about titanium drip shield nowadays. I'm talking about buried titanium basically and--buried titanium. As far as I know, there is virtually no experience anywhere for half buried titanium for probably no time, let alone one or two years.

VOEGELE: Right.

SAGÜÉS: The fact that we are taking a material in a set of conditions for which there is virtually no experience, is there any way of including that fact in this analysis to account for the uncertainty that results from this situation?

VOEGELE: I think the best way to answer that question is to tell you that we identified it as a factor which is important to performance which makes it a high probability candidate for doing the types of experiments that you're talking about. What we're trying to do here is identify that there is more benefit to our long-term performance demonstration from the components up here than apparently to the components down here. So, this is identifying the need to strengthen our ability to defend the titanium drip shields, if you will.

SAGÜÉS: Yeah, I guess, I mention this because more than the strengthening ability to see what is going to happen, I would say to create the ability to do that. Of course, at this time, there is virtually no engineering really base to rely on that. Engineering really based on actual experience.

KNOPMAN: Priscilla?

NELSON: Can you give me some examples of the kinds of simplifications you might be thinking about achieving?

VOEGELE: Right. Well, the ultimate goal would be to find a way to simplify the presentation and that would mean if we can find an absolute bounding number, pick one, you know, net infiltration above the mountain, that said we could demonstrate convincingly that the infiltration would never go above this number, then we would try to build an argument that said we don't need to look at the probabilistic distribution of those results because we will bound it by number which we all will agree is one that can't be exceeded. So, if it meets the performance with margins without considering the true performance of that system, but rather by bounding it, a number that it can't be bigger than, that would be something that we could simplify the analyses.

NELSON: Okay. So, that's really like the option of removing a variable almost?

VOEGELE: It's in the other direct--it's removing, but in a slightly different sense. It's saying that we're willing to accept performance that is poorer. Then, we might be able to demonstrate through a continued test program, and by doing that, we will save the effort needed to demonstrate that and put that effort into another component where we might have more potential for return on the investment.

NELSON: Do you imagine combining any of the models for factors because you see them moving or impacting similarly or would you do it focusing on one model for one factor at a time? Is that the kind of simplification?

VOEGELE: Well, there are at least three parts to this. First of all, there's a difference between what will be going in the site recommendation documents and what we would envision could eventually go into a license application document. I think that the prospect of a lot of simplification is more attractive for the license application document as opposed to the site recommendation document. So, expect probably more realistic representations of materials--or of the components in the site recommendation document.

NELSON: And, it seems pretty important that such simplifications be kept track of for performance confirmation consideration?

VOEGELE: Yes. Yes. Yeah, I think that that question was actually at the table this morning from Dr. Bullen. You know, it has to do with developing a performance confirmation program to provide insights maybe to more information that it might seem on the surface. I mean, performance confirmation ultimately is something that's negotiated with your regulator in terms of what do you need to do to provide confidence that the conditions that have been set forth in your license are, in fact, going to be met and the performance confirmation provides a way to do that. And, depending on how those conditions are articulated, it may be appropriate to do measurements more like what Dr. Bullen was suggesting this morning. Something that goes beyond the conditions of the license which could result in not only confidence that the conditions were correct, but it could also result in changing of the conditions eventually as you got this information that said perhaps under an even more aggressive environment it performs better than we would have thought before we did that testing; therefore, you might be able to relax that condition on the license.

KNOPMAN: Paul?

CRAIG: Mike, this is a question that really follows on behind Dr. Sagüés, but I want to focus on the canister. Your analysis says you now appear to rely almost entirely on the waste package and drip shield to provide an adequate margin. In fact, when I look at your #7, I see that the natural barriers according to your analysis would give 10r/yr in the pre-10,000 years rising to about 100r/yr in the 20,000 or so period. So, clearly, you've got to have the engineered barriers and they have to do a lot. Now, with respect to the C-22 and the canister, there's been a lot of work on corrosion of the plain material, the unstressed material. But, at some stage in the game, you're going to have to weld these things together.

VOEGELE: Yes.

CRAIG: And, my question is where do you stand in analyzing the behavior of stressed C-22 in the Yucca Mountain environment? Can you defend the idea that those will not be subject to corrosion?

VOEGELE: No, the last thing I would try to do is to defend the idea that with the information we have today that those won't be subject to corrosion.

CRAIG: Well, what's the time table for getting that and will you have it before you--

VOEGELE: --probably can ask that question is Jim Blink, and if he's gone, I'm in trouble. Oh, Joe Farmer, okay. Joe, would you mind? While Joe is walking to the microphone --he's not in here? Okay.

CRAIG: Well, he may talk about it tomorrow.

VOEGELE: Please, let me--at least, let me respond to the observation that you made on that chart. I beg your indulgence, but that was not meant to be a compliance evaluation. The last thing in the world I wanted you to conclude from that chart was that we are trying to show that we can meet a particular standard. I was trying to use these as indicators of how we gained insight. There are many additional benefits, I believe, that are going to be into the PA models coming from data that's coming in right now. You're going to hear Bo talk about some of that tomorrow. There are changes. I mean, Bob probably will talk about potentials for enhancing the models that we use. These were, quite simply, the VA models with all of their faults and conservatisms. Then tended to be nominal. There may be much better performance in that natural system than we used in these charts. I just want to make sure that I don't--

SPEAKER: Well, there might be worse--

VOEGELE: That's true, there might be worse performance, also.

KNOPMAN: Jeff Wong?

WONG: My question sort of jumps around between three slides. On Page 12, Bullet #3, you say that your workshops conducted that the confidence would not be adequate for SR unless you could find out more about the natural systems. And then, on Page 13, you list some of the principal factors that you're interested in. Then, on the second bullet on

Page 14, you talk about opportunities for demonstrating enhanced performance. And, it looks like you're going to rely on again the engineered system. What more do you think you need to demonstrate that the natural system is contributing significantly?

VOEGELE: Well, I think that Bo Bodvarsson would tell you that matrix diffusion is a potential big contributor here. That's something we're just getting information and I'm not going to pretend to steal any thunder he might have for tomorrow if he's going to talk about that. The seepage threshold is a natural barrier component. Within the principal factors that we put down, the saturated zone performance, the retardation in the unsaturated zone, in the saturated zone, as well, the solubility limits, the seepage in the drift, quite a bit of that is focused on the natural barrier if you want to put Slide 13 up.

WONG: Right. I'm saying what more information do you need physically?

VOEGELE: Physical test information?

WONG: Right.i

VOEGELE: Okay. I think, Jean is going to talk about that yet this afternoon. But, she's going to go through this same set of information with respect to which test programs are addressing this and what kind of information we're trying to gain.

KNOPMAN: Jared?

COHON: I have a question about this chart actually and the implications of it. You may have covered this and I missed it. If I'm going over old ground, I apologize. But, as an example, the first five other factors in climate through coupled processes, clearly are linked to the first principal factor, seepage into drifts.

VOEGELE: Right.

COHON: Is the implication of this characterization that from this point on, you're going to focus on the parameter of seepage in the drifts without worrying too much about why seepage would be some number other than another number? That is you're not going to put too much in climate or any of these other factors?

VOEGELE: I wouldn't say we would not look at them, at all. What I would say this indicates to you is that of the triad or quadruple, whatever you call that, of these things that start with climate, net infiltration, UZ flow of the repository, and seepage into drifts, the one to which performance is most sensitive is the seepage into the drift. I think that's what all this is telling you. That given a wide range of climate scenarios, how much of that actually drips onto a waste package is more important than the variability in the climate itself.

COHON: It seems to me to have confidence in any particular seepage values though, you'd have to have some appreciation for what's driving that seepage number like climate, net infiltration, UZ flow, etcetera.

VOEGELE: Right.

COHON: So, I'm just wondering in terms of what you do day to day, that is the analysis you're going to go through now, I'm wondering if this is setting you up then to focus just on the seepage number without worrying about these five other factors which underlie or integrate into the seepage?

VOEGELE: I would say that the answer to that is no. I think, Bob--are you going to cover that in your next talk? Okay. The talks are set up. I think, Bob will address that, as well, because he's got some charts that show basically what this means in terms of PA space.

COHON: All right. Could we go to Slide 10, please? Could you explain the drift invert and how it contributes to performance?

VOEGELE: Oh, it would just simply provide a diffusive variable of the waste package.

COHON: And, what's the assumption for its composition? What's it made of?

VOEGELE: Did we get the ballast, the gravel ballast into this? Probably a tuff gravel ballast.

COHON: Okay. I've been sitting here looking at these trying to develop some insight and understanding into the system and how it operates. I'd like to try something out on you and see whether I'm way off base or not. This is a gross generalization, but let me try it anyhow. It's tempting to say that the effect of the natural barriers generally is to shift in time what the dose would be. Whereas, the timely effect of the engineered barrier is not only to affect time is to affect the amount, the magnitude of the dose. Now, I know there are exceptions to that. But, would you sort of go along--delays the waste pack, the engineered barriers control magnitude. Could you put, I think, it's #7 or 8? I have them all over the--

VOEGELE: Probably 7. 7, yeah, I believe so.

COHON: Right.

VOEGELE: And then, could you put--I think I probably can answer it from this. It is attempting to say that the engineered components shift these in space just as you had concluded that the natural barriers shifted in space. Okay? Now, this is complicated by the fact that a lot of these curies here are decaying away. They're much shorter lived curies that are decaying away at that point in time and what's coming in are some of the daughter products at the later point in time. So, you'd have to separate the decay process and the ingrowth process from your conclusion about whether that's actually shifting it out to a later time. I don't know if that points out an answer to your question, but--

COHON: No, it is. It is.

VOEGELE: Okay.

COHON: Thank you.

KNOPMAN: Dan Bullen?

BULLEN: At the risk of beating a dead horse, let's go back to 13 again.

VOEGELE: Okay.

BULLEN: Let me ask a couple of quick questions. I'm assuming and it's going to sound even worse when I say cladding again, but is the cladding credit in the civilian spent nuclear fuel waste form performance? Is that where you want it?

VOEGELE: Yes.

BULLEN: And, I guess, the question is if you're taking cladding credit always and yet you're looking at it as an enhancement in other--addressing particular opportunities for enhanced performance as cladding performance, how can it not be a principal factor? I guess, I want to know how the process went that cladding didn't end up being a principal factor in your evaluation? I mean, maybe you don't know the answer to that, but--

VOEGELE: Oh, I think a lot of it has to do with--remember that this is more than just a neutralization analysis. These are the principal investigators and scientists' perspectives on the model uncertainties and the data uncertainties, as well, and I think there is a real concern about ever being able to demonstrate a lot of performance from the cladding. The cladding could easily turn out to be one where we could reach through some negotiation process and some testing process a limit that says you can have--you know, the best way to treat cladding is to assume one pinhole failure in each rod and then treat it that way. That is a simplification type analysis as opposed to something up here. But, we're talking about trying to focus the program's efforts on understanding the intricacies of the performance. I think that also is a reason why it would split. Cladding is actually, I think, on the list of things that--there are particulates on Page 14. It is one the list--it is one which is a candidate to flip up there on top.

BULLEN: Well, that is the one that I called upon because it seems to me that all the analyses we had seen previously you had already taken cladding credit. So, it should have been a principal factor. And, I guess, to see it either--I mean, waste form performance is something that you can take credit for if you can quantify it. My only concern about civilian spent nuclear fuel cladding credit is that it's going to be a real bear to go and try and license any performance for it. If you want to indeed, however, in all your analyses taking cladding credit, then you've already made it a principal factor, haven't you, or is it--

VOEGELE: No, I think again I have to call your attention that these were not compliance evaluations; these were scoring calculations to give us insight. And, what this led us--this together with the information on data, availability, and model uncertainty did not--nobody in our working group was willing to follow the sword to argue that cladding should have been a principal factor.

COHON: Okay. But, you know, cladding was used in all the analyses prior to that--

VOEGELE: Exactly. What we were really telling you is we think we understood the difficulty in eventually demonstrating that performance in a compliance evaluation.

COHON: Okay, thank you.

KNOPMAN: Bill Barnard?

BARNARD: Mike, on Slide 13, the principal factors, are they listed in order of importance?

VOEGELE: No. These?

BARNARD: Yes.

VOEGELE: No, they're listed in their order of top of the mountain down to the water table and out. We just pulled them up and lifted them up there.

BARNARD: Is it possible to list them in order of importance?

VOEGELE: Based on this evaluation, you would conclude it's probably the waste package and the drip shield.

BARNARD: Okay.

VOEGELE: Those are good for four or five orders of magnitude in this evaluation. The combined retardation is also about four as a magnitude. So, it's not that far behind int his evaluation.

BARNARD: Okay, thank you.

KNOPMAN: Any further Board questions?

(No response.)

KNOPMAN: I have one question, Mike. The coupled processes that are on the other factors list, I assume you mean they're thermal--where you're getting hydrothermal processes.

VOEGELE: Right. Yes.

KNOPMAN: Is it a fair characterization to say that as a consequence of the design evaluation process that you just went through and the possible relaxation of the closure period, the day of closure, that those factors bumped down to the other factors, but for had you not made that alteration when you were assuming closure of the repository, the coupled processes very much would have warranted a designation of principal factors?

VOEGELE: It's tempting to say yes, but I don't think so. I think that the situation here is one that we have not looked at great details on what happens within these components and these models. So that our neutralization analyses at the level we did them were not capable of really separating the results out of this, as well. There are some unanswered questions within our group about how to do some analyses to investigate whether or not there are thermocouple effects that should be considered as principal factors. I think it's--I can no longer tell where I am. It's one of the earlier pages where we talked about the--well, I give up. One of the pages in these viewgraphs talks about--I can't find it. If you'd give me a minute, maybe I can give you the answer later. But, enhanced thermal performance is something that has not yet been completely factored into this. Remember, these are the VA models with what little simplifications we--what additional model tweaking we could do to try to capture the EDA II design.

KNOPMAN: But, isn't your changing view of what the design is likely to be affecting your--

VOEGELE: Absolutely. That's why I said I'd like to say yes.

KNOPMAN: Okay.

VOEGELE: There are some more investigations that need to be done through PA sensitivity calculations or through these types of evaluations to further investigate that.

KNOPMAN: Okay. Any further questions?

DI BELLA: Could you turn to Slide 4 for a moment? I'd like to call your attention to that left most figure where you have water dripping down to the repository drift level whereby capillary action it moves to either side. And, I think there's absolutely no question that that will happen if the drift is in perfect shape and the infiltration rate isn't too terribly high, but it can be pretty high. However, more likely, what's going to happen over time and because of thermal, mechanical, and seismic related forces, you're going to have changes in the contour of the roof, you're going to have collapse. My question now is what sort of experimental work is planned to see how that is going to affect one of your principal factors, that is seepage into the drift?

VOEGELE: I don't know if Jean's presentation has that much detail in it or if Bo is going to--Bo has left the room conveniently. Now, there he is. Do you want to comment on that, Bo? I guess, while Bo is walking up there, I'll at least comment that the process that results in this piece of rock degrading is going to result in the piece of rock above it strengthening and closing fractures as it builds an arch to carry that load. It's not just a definite given that as this rock begins to unravel that the cracks are going to get extended to the ground surface. There's a better situation where the load above it will be carried by effectively an arch and compression above that opening which will close the fractures.

BODVARSSON: I've been thinking about the best way to address this and this is a very good question as with laboratory experiments where you can actually control exactly the shape of the opening even though we have to scale it up to a drift scale. The project is performing rockfall studies, both for modeling studies and also some work that indicates that there are two ways you can go; either you can go--the seepage performance and that you will more and more likely get low seepage or it can have individual rockfall depending on the fractured surfaces. The project is looking at both of these options with models and also planning some laboratory experiments.

KNOPMAN: Thank you.

Any further questions?

(No response.)

KNOPMAN: Okay. Thanks, Mike. I'm sorry?

ORESKES: I have a question about Figure 10 under the engineered barriers. You talk about the other changes besides the waste package neutralization and the cladding as being "very minor". But, if you look at your graph, it seems that the main effect of the drift invert and the drip shield is to shift the timing of the first release by quite a significant amount and up to, say, 2500 years versus 10,000. So, I'm just wondering how you understand that? I understand that the magnitude of the changes very much last, but why is it that you consider the timing of the change to be minor?

VOEGELE: I guess I'm not really certain that timing was addressed explicitly in my statement other changes are minor. I think I was looking--we were not looking at the timing; we were looking at magnitude of releases in these, as well.

ORESKES: Okay. So, are there separate studies that deal with the question of the timing of the release or that's just not addressed in this study?

VOEGELE: Well, no, it--I think that by the time you see Bob Andrews' eventual performance assessment calculations, there will be sensitivity studies from which you can glean information by the timing of the releases related to this. I don't know--let me put it it's certainly something worth looking at. I mean, timing can be as important as the actual magnitude of the release and it shifts the whole curve far enough to the right. So, I think I would rather take that as a comment and that's something we could look at.

ORESKES: Very good. Thanks.

KNOPMAN: Okay. Thanks, Mike.

Our next speaker is Bob Andrews who will talk about the implementation of the repository safety strategy in TSPA-SR. Bob is the manager of performance assessment operations for the M&O.

ANDREWS: What we're going to be doing for the next 20 or 30 minutes or so is walking through the implementation of the repository safety strategy that Abe talked to you this morning and Mike talked about at the second go within the context of the total system performance assessment.

If we can go to the first slide, we're going to walk through what is the TSPA as part of the repository safety strategy, walk quickly through the objectives and scope of the TSPA for the SR and talk to some of the differences of those objectives and the scope between the VA and the SR and address some of those changes and what we're doing about those changes. Some of those changes revolve around the regulatory changes that were talked about by EPA this morning and I know the Board had other presentations from NRC earlier. Some of those are a wide variety of comments and critiques of the viability assessment TSPA and, of course, there are a wide range of improvements in the analysis and the models that support the site recommendation as science has progressed, as additional data happened to come on line, etcetera. And then, we'll finally close with the actual contents as we see them right now of the TSPA for the site recommendation.

Just to reiterate a slide that Abe had up here on the five elements of the repository safety strategy, the first three of these either directly or indirectly relate to total system performance assessment. The first one is an explicit on. It's do the calculations to evaluate how this system behaves, how we think it performs, plus the appropriate uncertainty analyses that allow one to evaluate the "expected" performance. And, we'll get through that word "expected" which has a probabilistic connotation a little bit later. It's also used to do the sensitivity analyses, the important analyses of what drove the system. How did each of the individual components, each of the individual barriers contribute to that overall system performance? And, finally, does the evaluation, the direct incorporation of all relevant features, events, and processes, not just the disruptive ones, but all of them that may materially affect the long-term performance of the system?

Start off with some very global objectives for the TSPA-SR. It's part of the technical basis for DOE decisions that are going to be coming in the next couple of years on site suitability and site recommendations. It's not the only part. There's a lot of other technical information, a lot of confidence building, external reviews, etcetera, that provide that technical basis, but the TSPA is at least one element of that overall family of total information. It does evaluate the system compliance with those postclosure performance requirements and we'll come to what those performance requirements are in a second. And then, finally, and very importantly, it evaluates the significance of each contributing barrier, whether that's a barrier to water ingress or whether that's a barrier to nuclide egress from the system.

To meet those objectives, the scope of the TSPA for a site recommendation is to first off develop and apply the methodology consistent with the regulatory requirements. I'm going to come to that here in a second. The second bullet is very important, use representative models. I put the word "reasonably" in there; there was a lot of discussion this morning on what is reasonable and there will be a lot of discussion tomorrow on what is defensible, but there is always a play between--and it came up in, I think, in some of the discussions and the questions and answers with EPA staff --where does the applicant feel they want to be with respect to reasonableness versus defensibility? It is sometimes easier to bound something, i.e. push things to the limit, rather than take an expected value or even a range of expected values because that might be more defensible or easier to defend than trying to defend the actual range of the parameter of models that are incorporated. So, there's a balance between a reasonable representation and defensibility that's always played out. We'll come to some examples of that and there's some more examples in the backup to the presentation.

Finally is to calculate that expected dose and there's some other performance measures along the way that we'll come to. Evaluate the sensitivity to the uncertainties and finally and very importantly something that we try to continually improve with and, of course, take a lot of comments from a lot of groups to try to document these assessments because they are somewhat complex. There's a lot of individual parts going into a total system performance assessment, but to document those in some way so to show how transparent the results are, how the results are the way they are, and that they're traceable back to scientific underpinnings, back to raw data if you will and process level models. So, that's a continual goal that we strive for and, you know, sometimes we are close to meeting that goal, and clearly with some of the comments, other times not.

What are the factors driving our changes from the VA total system performance assessment to the SR total system performance assessment? First, there's a change in repository safety strategy that both Abe and Mike talked to. These are in no particular order of importance just so you're aware that these are the drivers to our change. Secondly, are the changes in the regulatory requirements. We talked about three site-specific requirements; EPA requirements that are site-specific, NRC requirements that are site-specific, and you heard both Lake and Steve talk this morning about DOE changing to some site-specific criteria for performance assessment. There's also acceptance criteria within the total system performance assessment, issue resolutions, status report from NRC, and also the individual key--issue resolution status reports or acceptance criteria for what the NRC, the regulator, thinks is a minimum necessary sufficient set of information for them to make reasoned decisions.

It's also driven by a number of external/internal reviews of the VA. I won't talk to those explicitly, but some of the flavor of the review comments that we received and our path forward to address those comments hopefully will come out as I go forward. There's a lot of new and revised site and design information. Of course, the design changed from the VA to the SR design and there's a lot of increased data and models to support the SR analyses. Some of those changes Mark Peters is going to talk about and Jean will also talk about additional data being collected and revisions of models.

Design change, I have there. And, also, finally last but not least, improved QA processes and procedures drive us to change. I will not talk to the last two bullets, but mostly, you know, by myself for the first four.

Starting with the change in regulatory requirements, just to put up not for you to memorize or anything, but that the need of requirement to conduct a performance assessment is driven by 63.113, NRC. There's similar words that I put in the back of your handout that are EPA's requirements for performance assessment. The next slide goes into the definition of performance assessment from NRC. In the back of your handout, I put the definition of performance assessment that EPA has in 197. There are slight nuance differences between NRC and EPA requirements which I'll come to in a little bit and there's very slight differences in the definition of performance assessment, but they're essentially, at least as an implementer's point of view, the same. Just NRC--just so we're on the same page--you know, the first step is to identify the features, events, and processes that could affect performance, examine the effects of those on performance, and finally to estimate the expected annual dose to the average member of a critical group as a result of potential releases from the repository.

The next two slides, I want to spend a little time on because these might look like nuances, and if they are, maybe I should go through them quickly, but they are important nuances of doing performance assessment. And, in the middle column, I have the VA requirements, if you will, what we were trying to do in the VA. On the right hand side, I talk to the site recommendation consideration report, the types of analyses that will be performed.

Starting first with the performance measure, the VA did use dose as a performance measure. The SR will do dose and, as you heard this morning, there's a separate requirement for groundwater protection that really relates to concentration.

The criteria, in the VA, as specified by Congress, was probable behavior. In the SR, it's driven by regulatory requirements in Part 63 as expected dose. The difference between probable behavior and expected dose, you might say to most people in the English language, is minimal, but clearly our peer review of the VA thought determining probable behavior was--I'm going to paraphrase here a little bit--an impossible task. But, determining the expected behavior per regulatory requirement with some reasonable assurance was a very doable task.

The group that we looked at for the VA was a rural residential farmer. The groups or individuals for the SR is --these might be the same. That's to be determined, I think, but either an average member of a critical group which is Part 63 or the reasonably maximally exposed individual which is the current language in Part 197. It may very well be that this individual is a subset of this group. That's how we currently look at it, anyway.

The location of the VA was at 20 km. The location in the SR, we will look at probably a number of different distances because the regulations are not set right now. If they become set in the next six months, that will redefine our work probably a little more specifically.

In the VA, we looked at peak doses out to a million years. We generally looked at different time slices just for presentation purposes, 10,000, 100,000, and a million, but we always ran things out to a million years. For the SR, we will concentrate because 197 and 63 both concentrate on 10,000 years. However, for two reasons, we will look at longer times frames. One is it gives you some additional confidence of how the longer term performance resides and, two, is 197, Part 30, whichever, for the FEIS. The final Environmental Impact Statement requires an assessment of the million year kind of time frame.

Continuing on the next page with additional changes between the VA and the SR for total system performance, the features, events, and processes, in the VA, those were analyzed separately. They were just one-off calculations, treatment of human intrusion, treatment of seismic effects, treatment of volcanic effects, treatment of criticality effects. The SR will first do a formal screening of all relevant features, events, and processes which was that first step of Part 63 and then explicitly include them in the calculation of expected dose so long as their probability is greater than that nominal cutoff in Part 63 and 197, 10^{-4} in 10^{4} years. So, they are explicitly in the calculation. They can be pulled apart for examination of conditional effects which is, I think, a very useful way to look at results. It's a way that I think NRC has proposed to us that we do things and I think we will continue to do that. So, we will pull the results apart to show the conditional effect of combining them back again to evaluate the expected dose.

Human intrusion, in the VA with a stylized calculation and the SR is going to be a stylized calculation.

The uncertainty analyses, both the VA and SR are going to be probabilistic analyses. There is a very slight nuance. The VA essentially looked at the mean of peaks, looked at a wide range of distributions and took the mean of the peaks. The SR per Part 63 and per our implementation of Part 63 will really look at a peak of means. It's looking at the expected or the mean performance and looking at the peak of that expected or mean performance which clearly has a distribution around it and that distribution would be shown around it, but it's a slightly different performance measure. Last summer, we did show one plot in the VA of the peak of means. So, we showed it once, but all the other plots that are in Volume 3 of the VA are the mean of peaks. So, it's just a slight difference.

In terms of multi-barrier analyses, what we did in the VA was we did sensitivity analyses, we did a lot of one-off sensitivity analyses, looking at 5th percentile, 95th percentile effects. For the SR, some of that work will continue, but it will be expanded dramatically to look at explicitly the barrier importance. So, that gives you, I think, a flavor for the types of differences between the implementation point of view between the VA and the SR.

Now, I have one slide that's more a pictorial of the performance assessment method not to be tutorial. And then, I have a slide that will come up next that will walk through the process. So, for those of you who like pictures, you can stay on the method slightly revised from the VA because how we document things in the SR is slightly different from the VA. In the VA, you'll remember we had the TSPA and then we had this technical basis document that provided the scientific basis for the abstractions generally used in the performance assessment. That technical basis document generally didn't go back all the way to the process model or back to the data. In the SR, we're using--and Mike Lugo will go into this in more detail--the concept of these Process Model Reports which are, more or less, broken out the same way as the technical basis document, but include the abstraction, the process model, and the supporting data and testing information that's to support that process model and its abstraction.

Walking through the method, we first start with the regulatory framework. The first step is then the FEPs screening. Let's go on to the next one. And, that FEPs screening is slightly different than what was implemented in the VA. It's going to be an explicit identification and classification. We have a database that incorporates all of the features, events, and processes. An explicit screening based on either probability criterion and both 197 and 63 give that probability criteria and that's the 10^{-4} in 10^{4} year or a consequence criteria. Finally, construct the scenarios and screen the scenarios using those same criteria and then within the performance assessment implement all of the retained scenarios.

Let's go on to the next. Once we've done that screening, we will have a series of scenarios which will be appropriately probability weighted such that the sum of probabilities equals one. We have the component models and the model abstractions that are described in the analyses model reports that Mike Lugo will talk to. We will then do these and once those are all combined into their abstractions--and I'll come to how we're doing that in a second--we're doing the 10,000 year total system model simulations and we'll do these--we're going to focus on the probabilistic analyses, i.e. the uncertainly analyses and purported range of parameters and the range of models, but oftentimes it's illuminating and it's illuminating for discussion purposes and very illuminating for transparency purposes to look at single value realizations and make sure that the system or the individual components are hooked up appropriately and that you're getting reasonable transfer of information both in terms of mass, water, nuclides between the various barriers. So, that's very illuminating. Essentially, what Mike Voegele was showing you was a series of deterministic calculations, not the probabilistic type of calculations.

We will then combine the results of these probabilistic analyses to get that expected dose history over the 10,000 and longer time periods and we'll do a wide range of sensitivity analyses, both probabilistic and deterministic, but probably focus more on the probabilistic ones to evaluate the significance of the barriers.

And, finally, we'll document these results with a compliance evaluation which will be in Volume 2 of the SR considerations report, revise the safety case next summer, as Mike and Abe both alluded to, and identify the key information for performance confirmation.

This is the approach for not including human intrusion into the analyses. This second slide essentially is the approach and the requirements for the stylized human intrusion calculation that will use the nominal scenario. We're not going to combine, at least right now, a human intrusion event with a volcanic event, but we will use a nominal scenario and run that through. It's also probabilistic. It will have an expected dose attributed to that human intrusion event.

And then, finally, similar things shown for the longer than 10,000 year requirement. 63 and 197, the base requirement, is 10,000 years, but the FEIS, the final Environmental Impact Statement, as proposed in 197.30 is to go out to peak. Our current thinking is those peaks, we may look at both deterministic type results and probabilistic type results. There was no requirement in 197 to look at it probabilistically. So, we may, in fact, use deterministic type results to show.

Okay. The next slide is a slight shift of gears to the major categories of concerns raised based on Volume 3 of the VA which is the TSPA. The first two, traceability and transparency, then the how did we treat alternative models, how did we screen them in, screen them out, did we weight them, etcetera. A lot of people commented on the major assumptions and did you evaluate the significance of all of your assumptions as you went through the analyses. And, finally, the last bullet which is, I think, of some discussion for tomorrow is the validity or confidence that we have in the individual component parts that make up the TSPA.

Traceability starts really with--this is, of course, the PA pyramid rather than the SR pyramid that Steve showed you. It starts with basic fundamental site and design specific information. The test data, the laboratory test data, the institute test data. It builds through the process models which are going to be captured in these Process Model Reports that Mike Lugo will talk to you about and continues on with the incorporation of those abstractions and the process models and analyses results into the total system performance assessment. You know, the TSPA that we do for the SR is going to build on what we did for the viability assessment, what was done for the draft Environmental Impact Statement which was analogous--the same models were used in the draft EIS as are used in the viability assessment. It builds on ours and NRC's plus other people's including EPRI's experiences in running TSPAs.

Now, one of the things I want to talk to is how information flows into TSPA and through TSPA. What you have here--and I'm going to go through them in a second; just hold on--is the analyses model reports that are providing direct data feed into TSPA. So, there is a report or there will be a report that describes, for example, down here the EBS radionuclide transport model and its abstraction. That's directly incorporated as a file. Whether that's a table look up or a simple algebraic expression or whatever, one can tear that part of the model out. One could be bounded in that. One could be reasonable in that. One can incorporate uncertainty in each one of these boxes that are going into the TSPA.

Within the TSPA, there's a flow of information starting first with the degradation of the package, degradation of the waste form, transport through the EBS, transport through the unsaturated zone, transport through the saturated zone, transport through the biosphere, and ultimately a dose is predicted; so a time dependent arrival of nuclides at that point, wherever that point is, 20 km, 5 km, or whatever.

We're going to walk through over the next steps how that information is connected and moves from essentially left to right within the performance assessment. So, let's go to the next slide which just talks to the waste package degradation and the major feeds into waste package degradation. You know, climate and seepage and the EBS environments all impact waste package degradation. The waste package degradation abstraction here includes both drip shield and the package itself. So, it includes the titanium and its degradation processes and rate and uncertainty and the Alloy 22 waste package degradation rates and processes.

Those might, in fact, be impacted by seismic activity, by degradation of the drip shield, by seismic events, water dropfalls, etcetera. It may be shown that those seismic activity affects our minimal and have no consequence and, therefore, may be screened out of the analyses. But, for now, they're screened in.

Moving to the left, we have all of the aspects in the waste form which also include environmental factors, such as the waste form temperature, the in-package chemistry. The waste form degradation will be somewhat dependent on the colloid source. The actual release from the waste form will be dependent on the solubility concentrations or the inventory. Here comes igneous activity. Igneous activity wasn't in there for impacting the package because the assessments, so far, show if there is igneous activity, the package lifetime is not an issue. The package is gone.

Then, we're going to continue on to the right. Once I've done the waste form, I've got EBS transport again with environmental components coming in here and then distribution and changes in hydrology and chemistry inside the drift. Continuing on to the right, we have nuclide released to the UZ and there's a lot of unsaturated zone analyses and models to move nuclides through the unsaturated zone. Moving still to the right, we have the saturated zone.

You'll note that climate and infiltration--and there will be a driver on all of this thing because the climate states drive the hydrology and the hydrology drives a lot of the water movement through the unsaturated zone and the saturated zone. Finally, coming to the biosphere and here we have the biosphere dose conversion factors, igneous activity affecting the biosphere climate, and if there is any dilution at the well head due to the critical group using large volumes of water, that would be factored in in there. And, finally, as to the dose.

So, there's going to be a lot of changes in the models from the VA to the SR revised design, critiques, improvements. And, I tried to capture some of these in the backup slides. I didn't include it in the actual presentation, but there are a number of areas where we are going to use somewhat conservative bounded analyses and models where the complexity is just too high or the uncertainty is too great and it's just easier within the context of the site recommendation report confidence building to use what is a demonstrably and defensively conservative assumption rather than drawing on the full range of possible models or parameters within that component or system. Within the back of the document, I give some examples of that.

I talk about it on this slide, too. So, I simply said this. That we're going to use reasonable representations where they are of sufficient defensibilities, but in areas--and, by the way, this is a good philosophy, but the peer review clearly commented that to us and I think the Board in kind of echoing the peer review comments on the VA made very similar comments that if we do have a high degree of complexity or very high uncertainty, it's just much easier to do some more reasonably bounded representations, document them as such, show their effects, if you want to show how much conservatism you've included in the analyses, and we will use, as Mike talked to the safety case, i.e. the factors versus principal factors criteria as a basis, not the only basis, but a basis for distinguishing which things might be reasonably conservative and which things might be actual reasonable representations.

Uncertainty is included in all models and parameters, if appropriate. We went with a bounded value. We're going to fix that bounded value. If something is well enough known like inventory, we're going to fix that inventory. We're not going to look at uncertainty in every single parameter within the model.

Okay. The next series of slides and I don't want to go though each of them in any detail, but we haven't--the Board and others, not just the Board, raised the issue of transparency and traceability. I think we always struggle with the best way of communicating that both graphically and in the text as we write it. One of the things I'm going to try to do or what the next five slides essentially do is starting with the key attributes and the factors that Mike and Abe had on their viewgraph is walk first to the traceability side. The traceability is to these two columns. The traceability for the climate is back to that Analysis Model Report written by some individuals at the USGS that define the climate states, current knowledge on climates, the bases for those current knowledge and future climates, and how to project those climates change over the next 10,000 years.

So, this document, the USGS report, AMR, Analysis Model Report has the technical basis and has the datasets that we're using exactly in the TSPA. Same thing here with, for example, the UZ flow above the repository. This Analysis Model Report is based on the model that Dr. Bodvarsson is going to talk to you about tomorrow. He's going to talk about the technical basis for it, the validity in it. It's what we're using are its flow fields from that, and the percolation fluxes from that. So, it's a direct feed of data from that model directly into the TSPA. So, if there's any question about traceability, we go back to the source of that information and that's where the information is contained, the technical basis for it, the data to support that analysis or that model. So, that's a traceability point of view.

There's a transparency issue showing up, more or less on the right hand column. What are the individual components that drive total system performance? We in the VA, if you'll remember some of those pullout things in Chapter 4, I guess, try to walk through starting with waste package degradation--starting with seepage actually. Starting with seepage, the waste package degradation, the waste form degradation, to EBS release, to UZ release, to SC release, we tried to show how water moved through the system and how nuclides were projected to move through the system. That's essentially what we're trying to do here, too, is to look at various slices of the total system as they impact the total system performance. They're not really barriers because the barriers are more over here in the factors, but they are some system measures of performance to show transparency of how water nuclides move the system.

You have the other ones in your handout for completeness sake, but I'm going to--if John will quickly go through them and come to Slide 26 where we talk about this--okay, 25, mine is different. Okay. I was talking about the Rev.00 TSPA which is the TSPA available at the time of the considerations report. Steve told you the schedule for that. It's next September, September of 00. First it's developing and screening the FEPs. Second is to implement all of these controlled models and analyses and all those numbers in there are controlled models and analyses. The software is also controlled and the date flow between the models is also controlled. Evaluate the reasonable representation of the expected performance, incorporating that uncertainty that's within each of those component models directly including the effects of applicable disruptive events; i.e. those that can't be screened out based on probability or consequence. Conduct that and stylize to an intrusion analyses. And, conduct a sufficient amount of subsystem and system sensitivity analyses to evaluate the significance of the individual barriers and the contribution of those barriers to the total system performance.

The difference between Rev.00 and Rev.01, Rev.01 is--I think, it's April of '01, something like that. It's first off to acknowledge that we may get comments on Rev.00 and it would be nice to address those comments from wherever they came from as we go from Rev.00 to the Rev.01. It is subject to the public comments on Rev.00, TRB and NRC comment on Rev.00. If there are any significant changes in models or data that come from the time of Rev.00, we would, of course, address those in the time of Rev.01. If they're not significant, we'll document that they were not significant and move on, but any significant change would have to be addressed. Then, as additional data become qualified and if there is additional software qualification that occurs, the impact analyses of that increased qualification would be addressed as we go from Rev.00 to Rev.01.

So then, finally, we're trying to develop TSPA-SR that we feel is suitable for DOE decision making and suitable for interested parties to review with respect to its comprehensiveness, completeness, traceability, transparency that's consistent with all of the applicable regulations. And, yet, of course, we realize some of those regulations are yet evolving. You know, the actual distances are not quite fixed yet. So, we have a range of distances. There's slight nuance difference between maximum exposed individual and average member of critical group. Those differences, they know we have to be cognizant of and somehow address. We're revising and improving all of the component models. There is not a model, I don't believe, in the SR that's not going to be in some way, shape, or form different than the models used in the VA. We're documenting the technical defensibility of these models in the AMR, the Analysis Model Reports, and the Process Model Reports. Then, we're assuring ourselves that we conform to all the QA requirements to help and that's one aspect to help insure transparency and traceability. Clearly, there's a lot of other ways of in addition to this specified QA requirements that we're striving for to improve the presentation of this material for a wide range of audiences.

With that, I'll stop, Debra, and take whatever questions you may have.

KNOPMAN: I'm sure we don't have any questions.

ANDREWS: All right.

KNOPMAN: Dan Bullen?

BULLEN: This morning, Bob, we heard one of the reasons that the current design was selected was due to flexibility and the ability to modify either the operation or the emplacement scenario so that you could remain flexible for hot versus cold, high AML, area mass loading, versus low area mass loading. How do you maintain the flexibility in your TSPA modeling to address those kinds of issues?

ANDREWS: We can't address every design optimization study, clearly, in the time frame we have. But, we've selected a few major ones like 50 versus 125 years on ventilation. There's no high AML/low AML in that. It's moderately low AML with different ventilation schemes. So, we're treating that as, more or less, a sensitivity study.

We won't do every single realization--we'll probably bound the TSPA-SR on the 50 year ventilation, but we think that's a little more bounding from a postclosure performance impact perspective and we'll do the sensitivity analyses on 125 year. There are some design optimization tradeoff studies that will be conducted in the context of the SR, but most of those will be somewhat minimal. I mean, we're saying this is the design. This is the design for the purposes of the SR and here is our analyses of how that design performs. There's not a lot of optimization studies planned.

BULLEN: Okay. As a followon to that, if you could go back to Figure 18. It's 18 in mine; we'll see what it is here. It's the one with the multi-colored time line.

ANDREWS: Yeah.

BULLEN: 17, then. How does that sound? That's right, that 17. As you follow through on the center note, if you will--that one--as you follow through on the center note, are there specific AMRs and PMRs that fall into each one or are there multiple AMRs and PMRs and would it be best to sort of follow the logical step of PA as we've done before with waste package, waste form, EBS, UZ, SZ, and biosphere or is it better to follow and take a look at the PMRs you're trying to put together and the AMRs that feed into them? I guess, I'm trying to get sort of a sense of what's the best was to try and follow your attempts to make it traceable and transparent.

ANDREWS: Okay. You're talking to a PA guy.

BULLEN: I know, to a PA guy and I'm a PA panel--I'm actually talking with a PA panel chair hat on here because I'm sure we'll have a panel meeting about this in the future, but can you kind of give us a heads-up on what do you think the best way to follow it might be?

ANDREWS: Given that I'm a PA guy, I think the best way to follow it is the factors or analyses and models that impact each of the steps in a performance assessment, you know, they might be summarized in different PMRs. I mean, your question--you have two ways of slicing this--well, probably more than two. But, at least, two major ways of slicing this. You can slice it by, more or less, technical discipline which is more of less the PMRs are sliced. You have hydrology, you have coupled process, near-filed environment, you have waste package corrosion people, etcetera. You have discipline basis descriptions. Or you can slice this by those factors that intertwine to affect something that affects performance which are going in the bigger boxes here. Being a performance assessment person, I would probably look at all the factors that affect waste package degradation and look at that in one fell swoop. All the factors that affect waste form and UZ trend, no. So, I would go in here personally rather than by PMR. If somebody is a hydrologist and they want hydrology, they probably would go into the PMR. I think it just depends on whether you have a little more integrated hat or you're knowledge hat on. Quite frankly, it's an excellent question because NRC--you know, I don't know if they want to speak to this; they might --have the same issue. I mean the KTIs, the Key Technical Issues, are--biology. What they call key elements of subsystem abstraction, which I think they're going to rename now to the integrated subsystem issues, something like that, ISIs, those are things that integrate and impact performance. So, it just depends on which side of the bed you wake up on.

BULLEN: Thanks.

KNOPMAN: Jared?

COHON: On your Slide 9, if you could put that up, and 10 which comes after is a continuation of it, it seemed to me--well, right column calls this TSPA-SR, and if you hadn't given us the title, I would have thought that this was TSPA-LA. Is there any difference to you between SR and LA?

ANDREWS: In terms of the expectations of the types of analyses we do?

COHON: Yeah?

ANDREWS: No. In terms of individual component parts and how they're treated in the LA versus the SR, the answer might be yes.

COHON: Because we may learn more between--

ANDREWS: You may learn more, you may want to bound some things even more for the LA than you did in the SR.

COHON: Your answer disturbs me because the decision makers at the SR point are different from the decision makers at LA. You have to convince the President and the Congress, but you should know this then. That's different from convincing NRC.

ANDREWS: Correct.

COHON: Unless the President and the Congress are going to announce we're going to accept NRC criteria and that will be the basis for our decision. I think you have to give some more thought to what the President and the Congress will want to know. You said--this is a different question now. You said estimating probable behavior was an impossible task. That was your quote.

ANDREWS: I didn't say it. The peers did.

COHON: Yes, you did.

ANDREWS: The peer review said it.

COHON: The peer review said it was an impossible--do you agree with them?

ANDREWS: No.

COHON: And, they thought that expected dose was easier; that somehow that's not impossible, but probable behavior is?

ANDREWS: That's what they said.

COHON: Do you accept that? Do you agree with that?

ANDREWS: Their definition that--you don't have any peer review members here to defend themselves, but their definition of the word "probable" was essentially in the form of an exact prediction of behavior. We never said the VA was an exact prediction of behavior. We had a wide range of projected predictions. I think the expected dose requirement in Part 63 and the mean dose requirement in 197 factor all of that uncertainty in, allow you to still show the effect of that uncertainty, but factor that into the assessment of what is expected where expected now has a probabilistic connotation. It means mean dose.

COHON: So, in the peer review panel's interpretation, probable behavior did not have a probabilistic interpretation?

ANDREWS: That's correct. Well, I think, they would say that's correct.

COHON: Well, let's put the peer review panel aside for the moment. I'm pretty sure that you would agree that TSPA's greatest value is in helping the program and others to understand the full range of possible behavior/probable behaviors of the repository.

ANDREWS: Uh-huh.

COHON: And, probably less valuable in coming up with a number like expected dose. Now, the two are currently linked, I understand that. But, given all the uncertainties, given all the data uncertainties and the modeling uncertainties that are unavoidable, I would suggest the TSPA is most valuable in understanding probable behavior defined probabilistically in producing a number called expected dose.

One last question, in the back of slides, you talk about the process to estimate NRC's--that's all right. You don't have to go to it. Well, you can, if you want to. But, one of the components of it is the scenario probability. What is that and how do you compute that?

ANDREWS: We combine the individual features, events, and processes which all might have a discrete probability and as those are combined into scenarios, those discrete probabilities are combined into a weighted probability that combines both those.

COHON: So, you're going to make some assumptions about independence of these various submodels, the processes--

ANDREWS: In that case, yes, because it will be independent. The features, events, and processes are enough independent that that assumption would hold.

COHON: Okay. Thank you.

KNOPMAN: Leon Reiter?

REITER: Bob, a few questions. On this last item, as Jared was talking about, how are you going to treat model uncertainties. We saw like in the PVHA and PSHA, they included and weighted different models and the general approach in TSPA-VA was to do sensitivity tests. Are you going to include model uncertainties if the models in your probabilistic characterization as part of your--of expected dose and more of that?

ANDREWS: For some, yes.

REITER: For some?

ANDREWS: For some, we might go with the more bounded model and just stick with that model and show with a subsystem analysis why it was bounded. I'm not going to stand here right now, you know--

REITER: But, you're going to try and--what I'm saying is you're going to try and explicitly incorporate more model uncertainty in the SR-TSPA than you did in the VA?

ANDREWS: Yes.

REITER: Is that correct?

ANDREWS: Yes.

REITER: Okay. Let me ask just two questions. Dose security was brought up. For a while, we're sort of heard of rumors that you might continue the peer review. You might subject the TSPA to some sort of external review like the Nuclear Energy Agency. Is anything being planned in that?

ANDREWS: I don't know if DOE wants to--it's not in my scope, but maybe Steve or Abe want to talk to whether and how they might do that.

BROCOUM: For the next year or so, I don't really see that happening because basically, you know, we have enough to do. For the LA, we may consider something like that. But, we don't have any definite plans yet, but we have talked about it and some of us would like to do some of those things.

REITER: Okay. And, there's just one final question. In the tables, you showed possible subsystems performance measures. Now, it's interesting because what do you envision doing with that? Are you going to try and set up perhaps some sort of performance allocation or how are you going to use this kind of information?

ANDREWS: Well, one of the ways you can use it, I mean, the barrier of neutralization studies that Mike showed you really could have looked at the subsystem contribution rather than neutralize it and look at the effects on total system. But, if it's very illuminating, we have found and we think we found in the VA, especially where we communicated with people, to show how at each part of the system there is a contribution to system performance. I think, you know, Dr. Craig asked the question earlier to one of the speakers. You know, something to the effect of how can you show the impact of the different barriers and one way, of course, is to neutralize them and the other way is just to how at various points in space and the various points in time, you know, how the total inventory is moving through the system. Where is the total inventory? Where are the release rates at different points in space? And, you can look at those probabilistically because all of the results are sitting there. It's just a matter of parsing out the--from the system analysis at each one of those break points and then doing, more or less, an importance analysis and you could do a lot of different things with those results to look at the significance of each barrier, if you will, in space on the overall system performance. So, it's more of a barrier importance analysis kind of approach.

NELSON: I have two questions. One is the integrated site model, it's been a long time since I've seen it. So, I don't know what it looks like right now. I look forward to seeing it. But, I'm wondering to what extent that is really considered a model in the same sense that the other models that you talk about updating and changing are considered models. From the standpoint of different ways of characterizing various properties, whether it's fracture, non-fracture, equivalent continuum, for example, and other choices that are made about how it's conceived to create this model from which the PA is operated. Can you tell me something about that?

ANDREWS: Yeah, well, you're right. I mean, there's no processes imbedded in that particular model. It's just a geologic description and framework in which other processes work like hydrology and thermohydrology and transport. And, I have it on that slide as a feed into, I think, the UZ and SZ--sometimes there's only saturated zone--process models which are really looking at processes rather than a hunk of rock and how that rock, we think, looks.

NELSON: Well, as it relates to something like spatial variability, other ways of conceiving what's in the mountain, is that something that you might consider as a flexibility or a variability of that model or is it, more or less, just this is the model on which we operate and we don't expect to really update it or treat it as a source of uncertainty?

ANDREWS: I would answer probably in the latter category. The processes that act within it--and Bo can talk to this tomorrow--the processes that act within it, you know, might address variability of components and uncertainty of individual factors in that model, but that model itself is pretty static. It's not changing really.

NELSON: Okay. The second question I have deals with the fact that on the agenda it says that you were going to say something about natural analogues. I'm wondering how natural analogues are going to be considered in this?

ANDREWS: Well, the natural analogue part, I think who talked about it this morning a little bit, Steve or Abe? Each of the process models is to the best of their ability addressing some relevant analogues of those processes. In UZ, I know Bo is looking at things at Hanford plus NTS kind of information as additional confidence builders for the process level models. The only thing we're doing within a TSPA context is looking at the Pena Blanca and could we explain Pena Blanca with a system, you know, type model.

NELSON: So, your trying out your TSPA model on Pena Blanca?

ANDREWS: Uh-huh.

NELSON: And, that's the only linkage between PA and the natural analogue study?

ANDREWS: Well, the PA is built on all the process models. The process models are tied back to analogues. You know, it's hard to have an analogue for TSPA itself. There's analogues for biosphere. Clearly, there's--you know, like

Chernobyl and things like that. There's analogues for other parts of the system, but those are individual parts that have analogues, but TSPA itself doesn't have an analogue that I can think of unless maybe somewhere some time ago somebody really did both waste and--

KNOPMAN: Alberto?

SAGÜÉS: As far as in #10 in the uncertainty analysis, you refer to a mean of peaks versus a peak of means. Do I understand correctly that the peak of means approach is a more forgiving type of--

ANDREWS: No.

SAGÜÉS: No?

ANDREWS: No, just a different way of looking at the mean of a dose response. The peak of means would look at the mean at every time step or, you know, in Part 63, it says every year; it says annual. So, let's just use that. Annual mean value of the dose might be expected dose at each year of the analysis. That's not what we did in the VA. We ran a series of realizations, you know, and got 100--

SAGÜÉS: Right.

ANDREWS: And, we just looked and said where is the peak, you know, no matter in it occurs in the 10,000 or 100,000 year window.

SAGÜÉS: Right. I'm just saying that forgiving--that would be the mean of peaks in TSPA-VA would seem to be less forgiving because, say, suppose we have two realizations and one of them gives you a peak of 100 at, say, 3,000 years and another one gives you a peak of 100 at 6,000 years. Now, both of them have peaks of 100, right, and therefore the mean of the peaks would be 100? However, in the other case, if you ever reached them, then your means may not reach more than 50 or 30. That's what I'm saying, the one on the right appears to be more forgiving.

ANDREWS: It's possible. When we did the analysis in the VA and, you know, of course, Part 63--I'm not sure when we actually documented the VA whether Part 63 was out or not. So, we did a side-by-side comparison. We didn't draw a spotlight to it, but in Chapter 4 where we did it both different ways. And, over 10,000 years, they were in the decimal point difference. I mean, it was, you know, whatever the mean of the peaks versus peak of the means, it was like .04 and .042, or something like that. I mean, they were darn close to the same number.

SAGÜÉS: I see. And, is there the same--why the change?

ANDREWS: Because that person--well, maybe NRC can talk to this better than I. The peak of means sound like a more reasonable way to go because you're looking at the mean at` each time step. That individual who lives at year 3,000 is not the same individual who is living at the year 6500. So, it was a much more reasonable way to show means.

Tim McCarten?

SAGÜÉS: I see.

MCCARTEN: Tim McCarten, NRC. Yeah, that's correct. I mean, from the individual risk standpoint, the expected dose is because you want to look at the annual risk at a given time. The person at, say, 5,000 years is not getting the dose at, say, 8,000 years and adding those--taking the mean of that, it's not the same person. So, from an individual risk standpoint, we felt that was a more appropriate way to do it.

SAGÜÉS: Now, since you are there, how about from things such as, I don't know, genetic alterations and the like, wouldn't that be sort of a cumulative kind of thing?

MCCARTEN: Genetic-wise?

SAGÜÉS: Yeah, for example, if there are problems. Say, you have a given type of organism and then isn't that a generational kind of thing that would be cumulative?

MCCARTEN: Well, we're looking at the risk to latent cancer fatality.

KNOPMAN: Okay. Any further questions from the Board?

(No response.)

KNOPMAN: We are running a few minutes ahead of schedule and I would like to exercise the prerogative here of the Chair to insert a break where there is not one on the schedule. I'd like everyone back at five after 3:00 so that we can pretty much stick to the schedule, but we'll take a break now.

(Whereupon, a brief recess was taken.)

KNOPMAN: Mike Lugo who will talk to us about the Process Model Reports and the Analysis Model Reports and how that fits into the overall repository safety strategy.

LUGO: Well, every talk you've heard today has mentioned the term Process Model Report and Analysis Model Report and I guess I'll now tell you what that all means and how it fits into the documentation trail that we're putting in place for the SR.

First of all, the purpose of the Process Model Reports is to basically document the technical basis for the TSPA. It's the building blocks of the TSPA analysis to basically support the preclosure and the postclosure safety case as it evolves to SR and further developed into the LA. The PMRs together with the repository safety strategy that was discussed today will help focus the program on what's really important and what we need to do to develop a defensible TSPA. You know, that is what we're really depending on to make our postclosure compliance demonstration. The third bullet here is really the focus of my discussion here today which is to leave you with the process that we have put in place to ensure that we have a traceable and transparent total system performance assessment and why we do that for the SR.

This is not an outline or a table of contents for the PMR, but just a discussion of the topics that the PMRs will address. Number one, they will describe the actual models and the submodels and the abstractions, and by that, for example, I mean for like the UZ flow and transport that you'll hear about tomorrow from Bo. The UZ flow and transport Process Model Report will also discuss infiltration model, the climate model, the seepage model, etcetera, and the abstractions of those models into the TSPA.

The PMRs will also discuss the relevant data and the uncertainties in those datasets. And, also, I didn't put it on here, but it will also discuss the data qualification status and where we are along that process.

Any assumptions that have been used in developing the model and the data that support it, as well as the bases for those assumptions.

Also, the model results or outputs. Like I mentioned before, the same example, take the infiltration model and there's an input to that from the climate model, but there's also an output that goes to the seepage model. So, it will basically discuss the customer/supplier relationship in each of the PMRs.

It will also discuss software qualification and model validation and tomorrow you'll hear a lot about model validation, but it will discuss where we are along the process to qualify the software and to validate the models.

Very importantly, and this is something that Abe discussed this morning, it will discuss opposing views, as well as alternative interpretations of the data, both internally to the project, as well as external, and it will identify why the view that we chose or the position that is documented in the PMRs, we believe, is the correct way to proceed.

We'll also have information to support regulatory evaluations, but PMRs themselves are technical documents, not regulatory documents or regulatory compliance documents, but they will have the technical bases that you could use to actually make the regulatory case either for the SR and eventually for the LA. In particular, here, in Chapter 4 of the PMRs, we'll have a discussion of how the technical content of the PMR addresses the NRC's issue resolution status reports and acceptance criteria.

Also included, it's not on this list here, but also how the views of the TSPA peer review and other interested parties have been addressed in that model.

Dan Bullen earlier asked a question about how you trace and which is the best way to trace. I'll give you the two options here that Bob talked about. The way that the PMRs and AMRs in TSPA all fit together is as follows. You have the science and engineering, lab activities, literature search, the things that basically produce the information and the data that you're going to use to make your analysis. They also use the updated reference design that was discussed earlier by Steve Brocoum.

Right now, the Analysis Model Reports, we have about 148 of these reports. They're generally divided into two camps. The first one is a set of reports that actually address the process model itself or any analysis. For example, like I said, the climate model or if you have an analysis of some hydrologic data. So, these are in this camp over here. Then, there's another set which basically are the abstractions which Bob Andrews and his people do which take that information from the process side and abstract this to be used in the TSPA.

Now, this set of 148 AMRs has two customers. First, it's the TSPA analysis which are basically the rip code runs that Bob does and they also get synthesized, summarized, and put in context with respect to these nine Process Model Reports. The analyses themselves get documented into the TSPA document that Bob talked about that is due in December of '00 for the SR consideration report. This TSPA documentation will rely upon the Process Model Reports as its primary reference for the actual process model. If you'll remember, as Bob pointed out earlier, the technical basis document for the VA had many chapters to it to describe the process models. Well, this set of nine reports, in essence, replaces those set of chapters in the technical basis document. So, that this TSPA documentation primarily focused on the methodology, as well as the results of the TSPA. Then, of course, both of these gets referenced and used in the SR to provide the recommendation. The same process goes for Rev.00, as well as Rev.01.

Now, this chart was used earlier by Steve Brocoum, just the top half, and I'll discuss a little bit more about the bottom, as well. Like I said, the red boxes here is just a symbolic representation of the 148 Analysis Model Reports that support the nine PMRs and these are AMRs set to range anywhere from 3 for the integrated site model as much as to like 29 or so for the UZ flow and transport model. So, there's quite a variation of how many AMRs support each of these PMRs. These are the dates that would be the expected

DOE approval dates for each of these PMRs at which point that will be when it will be probably available.

These PMRs and the AMRs, like I said earlier, support the TSPA Rev.00 that is due in 9 of '00 which both then support the consideration report that will be issued to the public on 11 of '00. We would then expect here to revise the PMRs from not only to incorporate any comments received from Rev.00, any new information that comes in, discuss any developments in the pedigree of the data and the software qualification, any potential changes that may have occurred, and that's to rebut January of '01 to support the next revision of the TSPA that supports the SR.

Then, we have in our schedule a planned revision right now for Rev.02 which will be to support the LA. And, here, again we will be addressing any comments received from Rev.01. Between Rev.01 and Rev.02 is when we will be expecting to get the NRC's comments for the sufficiency comments to support the SR. Depending on when we get those and what this schedule ends up being, we'll see if we can address some of those concerns in Rev.02 to support the TSPA for LA, as well as the LA itself.

Now, let me go a little bit to the bottom here now. We talked about data qualification and software qualification and model validation earlier. We have some goals within the project that we've established recently. By the time we submit a Rev.00 of the PMRs, our goal would be to have 40 percent of the data qualified, the software qualified, as well as the models validated. By the time we get to Rev.01 of the PMRs, that would be up to 80 percent and then basically essentially completed by Rev.02.

Now, as Bob Andrews pointed out earlier, the primary technical basis for the consideration report is the Rev.00 of the AMRs, PMRs, and TSPA. So, basically, at this point in time, we would expect to have a pretty robust technical basis for the SR. Now, there has been a concern raised in the past as far as how far we're along this path on data qualification, etcetera, by the time we get to these different milestones. Well, it's true that the Rev.00 PMRs which are supported in the consideration report, by that time they would have been 40 percent. If you looked at the Rev.01 PMR for just January of '01 which is just a couple of months after the consideration report, we're basically close to the 80 percent goal at that point in time; so, by the time this goes out to the public and pretty much essentially completed by the time the SR goes out.

My last viewgraph here is to show you the project management system we have in place and the team; as I mentioned early-on, the managing of the whole effort to put together the nine PMRs. We have a team of nine PMR leads of which you'll hear from two of them tomorrow from Bo and from Joe. These PMR leads are matrix supported into me and they report to me on a matrix basis. However, they actually report administratively through the operations areas within the M&O. Listed here are also the DOE counterparts for each of these process models. I think one or two of them are here today.

We also have a PA representative whose primary role on the team is to make sure that they're working with the process model lead to make sure that the abstractions and the process models are coming together so that they can eventually be fed into TSPA. The PMR lead, himself or herself, are the ones who are wholly responsible for the ultimate technical integration and technical adequacy of the document.

We also have a regulatory representative on each team and their role is primarily to make sure that the evolving arguments in the PMRs are arguments that can be used to make the regulatory compliance demonstrations in the future primarily focused on the issue resolution status reports and on comments from external organizations.

We also have a QA rep on every team and their primary role is to make sure that the process we're following that I discussed earlier is being properly implemented. We want to make sure we don't get into some of the problems that we've had in the last few years with respect to traceability and transparency. So, they're there to help us out in making sure that the process is being implemented correctly.

So, with that, that was a quick overview of how the process works and I'll answer any questions you have.

KNOPMAN: All right. Thank you, Mike.

Any questions from the Board? Don Runnells?

RUNNELLS: A question about the QA procedure on your Slide #5. You have 40 percent, 80 percent, and completed. There must be data from the early days of the project that just cannot be qualified. I mean, things that were not anticipated. An example, I don't know, pick something, petrographic data. Someone studied rocks in the early days of the project and it's impossible to go back and qualify those kinds of data. Is that word completed up there truly 100 percent of the data that will be used in the PMRs will be qualified? Does it mean that you will toss away certain things that cannot be qualified?

LUGO: No, let me explain that. The percentages of qualification relates to those data that we believe need to be qualified to directly support the safety case basically and the PMRs. Now, there may be some need to use some data or some desire to use some data as corroborative data that you're indirectly relying upon to basically fill in or bolster your case, but not directly relying upon them. So, you may have--just to pick a number--100 datasets supporting a particular PMR, but which maybe only 70 or 90 of those need to actually be qualified. It doesn't mean you can't use the rest of the data. You're not going to throw it away, but you may use that to be able to show that the ones that you did use to directly support your safety case are corroborated.

RUNNELLS: Good, thank you. That helps.

KNOPMAN: Dan Bullen?

BULLEN: Mike, as a followon to that, I actually have a question on Slide 4 if you want to go back just one. But, first off, let me say that the more I learn about the PMR/AMR process, the more I'm impressed with how ambitious this is. I mean, you're trying to get your arms around the entire world with respect to data and trying to find out what's applicable and what's not.

LUGO: I've got big arms.

BULLEN: But, as I look at the red box there with the Analysis Modeling Reports going from analysis and process models to abstractions, I recall that when you had the abstraction process for TSPA-VA and you had the abstraction workshops and you had the expert elicitations, it was an extremely excruciating process to try and get the experts to tell you what the right number was and what number you're going to use. So, as I go back to the abstraction process again, I kind of want to know who decides what gets left behind and then what gets carried forward? How do you document this? How do you pick the right sets of data that are applicable to what you're doing and then, you know--well, separate the wheat from the chaff, for example, and decide what's chaff and what gets left behind. So, I guess I need to understand a little bit more in detail how you're going to do this 148 times and only keep the good stuff?

LUGO: Well, first of all, let me tell you there's about 100 AMR leads for these 148 reports, okay? We've asked each of them to tell us what information are they going to use to support their AMRs. Bob Andrews has also initiated a series of what I may call workshops or meetings between the abstractor, the PA representative, for example, and the people that support him, and the modeler or the PMR lead and the AMR lead. They've had those conversations and they're being documented, as far as the agreements that are being reached as far as what information flow I need, you know, what data I don't need. This is also being supplemented by the knowledge of the repository safety strategy. So, that's also relayed on that which Bob discussed a little bit earlier.

Yes, it's a tough chore, but we're doing it. You know, we're having those interactions and everything I hear from Bob, for example, and the other operations managers is that at the lower levels at the AMR level, everybody is talking to each other, things are going--you know, the exchange of information is occurring.

BULLEN: Okay. I guess, the followon question there would be how do you determine data sufficiency? How do you know when enough is enough? I mean, obviously, as scientists, we'd all love to go back and master every part of the mountain and understand every radionuclide as it goes, but in the case of something like this, you have to decide, okay, we know enough about this process that we can adequately put it into a Process Model Report and describe it. I guess, the understanding of how you decide that, yeah, this is what's necessary and this is what's sufficient is something that's sort of intriguing to, you know, the performance assessment panel chair who is trying to look at what you've done and decide, yeah, did that make sense or did they leave something out. How do you define sufficiency?

LUGO: Well, let me tell you just like Steve Brocoum answered one of his questions, there is no black and white answer to this, but it's a combination of things you have to balance. One is what is that technical person that's responsible for that report, what does he or she believe is technically defensible when they have to get up and defend it? Number two, they also have to consider what other people have said about that like the discussion we had over there on cladding. Some people may think internally we can support cladding; other people say, no, we're not going to be able to support defending it. So, maybe let's not up-play that too much. So, you've got to balance those two; not only what you think is defensible and what you think other people that are going to be critiquing you and overseeing you think is defensible.

BULLEN: And, all of this will be either in the AMRs or the PMRs so we'll be able to see the decision process or the thought process?

LUGO: Yeah, this section of the AMRs themselves are the building blocks of the core technical data under core technical arguments. The PMRs themselves, there may be exceptions here or there, but they're not really intended to come up with new information. They're pretty much summarizing what's in the AMRs and putting them, you know, in perspective with respect to the one overall process model. But, it's really the AMRs where you see the guts of all the technical arguments and discussion.

BULLEN: And, Leon just handed me--I think it was Leon--handed me a little note here. Will you use expert elicitation in TSPA-SR? Will there be an expert elicitation process in that or--

LUGO: I'll let Steve handle that one.

BROCOUM: Another one of those tough questions. I'm not sure what our plans are. Is that a question for me to answer or a question for you to answer?

LUGO: I don't know. Bob, do you use experts in TSPA-SR or not?

ANDREWS: The only two expert elicitation results that will be used in the SR are the probabilistic volcanic hazard assessment which was an expert elicitation and the probabilistic seismic hazard assessment which was also an expert elicitation. Those two will be used as direct inputs, you know, into the seismic risk and volcanic risk for the disruptive events. The other inputs, you know, will not be directly used; they might be indirectly used as either confirmatory information or conflicting information that has to be evaluated and addressed. But, not directly used quantitatively in the assessment.

LUGO: Okay, thank you.

KNOPMAN: I have a question. I'm all for decentralization as much as possible, but I'm a little bit puzzled about the autonomy you appear to be giving to those kind of responsible for each of the individual AMRs in terms of setting a standard for themselves on data sufficiency. While I realize you can't be rigid about this, it seems to me that, for example, having some vague idea of the way you want to represent variability for a given parameter or model uncertainty and the way in which you'd want to be able to bound model uncertainty will require consistency from AMR to AMR, if at some point someone is going to talk about the accumulation or the cumulative uncertainty that has built up and then will ripple through the abstraction process into TSPA analysis. And, if it's a cacophony of voices there on how important uncertainty is and what that notion of uncertainty is for key parameters, I don't see how you make sense of that at the end. So, what kind of guidance do you give in terms of the way you want parameters to be represented statistically and models and model uncertainty?

LUGO: Okay. If I left you with that impression, I didn't mean to. There's not so much autonomy at the AMR level. Like I mentioned before, the PMR lead in each case is the one that we're holding ultimately responsible and accountable for the technical integration and technical adequacy of the PMR and its supporting AMRs. Okay? What we have done is I've gone to the AMR leads to get that information, but it has been vented through primarily these two individuals here which is the PMR lead as it fits together with that whole PMR, as well as the PA representative, and how it fits together into the TSPA. And, all of that, the primary guidance that we have been supplying has to do with the repository safety strategy and the relative importance of the different factors. Like was mentioned before with Mike Voegele, we are using that repository safety strategy to prioritize the information that we're going to use.

KNOPMAN: Well, let me put it this way. I'd be interested in seeing in writing the part of the repository safety strategy that speaks to kind of the standard by which uncertainty is going to--parameter uncertainty will be represented, as well as model uncertainty. I'd like to see what kind of guidance is being given to each of these PMR leads so that--it's an important issue for the Board to understand what that is.

LUGO: Let me ask Bob. Is this also in the TSPA methodology and assumptions document?

ANDREWS: What we've done in the methodology and assumption document is, first off, put which AMRs are providing that last, if you will, parameter feed and how the uncertainty in that parameter is expected. You know, the actual range of uncertainty that that parameter or alternative model has is right now really up to the AMR--the key technical people who understand that issue because we're asking them to defend that range of uncertainty and they are closest to that technical issue, they are closest to the comments received on that technical component whether those comments have been from this Board or NRC or our own peer review. So, they understand the technical scientific questions associated with their component of the system better than anybody else. They're the ones that have to defend it. And, like what Mike said is 100 percent right; if in the case, especially of the factors, it is easier for them to defensibly bound it and take the uncertainty with respect to that factor, more or less, off the table, then that's okay based on the factor versus principle factor division. But, that's on a really scientific technical area by technical area basis.

KNOPMAN: Let me just make sure I understand. If you end up with a parameter that's bounded, you say it's taken off the table, but it's still part of the modeling process.

ANDREWS: It's still part of the model, yes.

KNOPMAN: Are you then using those bounds or are you taking a mean?

ANDREWS: Reasonable bound.

KNOPMAN: What?

ANDREWS: For that component of the system.

KNOPMAN: That's for the probabilistic analysis, but you're also doing a deterministic analysis.

ANDREWS: Which would still use that bound.

KNOPMAN: Well, you have to run it twice. You have an upper and a lower so it's--

ANDREWS: No, we're going to look at the conservative bound and one that worsens the performance.

KNOPMAN: You'll take the worst bound?

ANDREWS: Yeah, yeah, yeah.

KNOPMAN: Okay. I hope it will be in your effort to convey transparency that all of the--I mean, you've got thousands of parameters, only a few are probably really drivers, but that it will be relatively easy for us and for other members of the public to be able to identify what those bounds look like on those parameters, as well as what the uncertainty in model--we'll be getting to a discussion of model invalidation and validation issues later, but that will be obvious, too, and we're not going to have to go to a 10th level document to dig that out.

ANDREWS: We agree.

KNOPMAN: Okay. Any other questions from the Board or staff?

COHON: Could you go to Slide 5, please; the little bar on the bottom that you talked about before, the data qualification, etcetera. The way you talked about it and the way you presented it suggest that those three things move in lockstep. That is data qualification, software, model validation are all at 40 percent, all 80 percent, all complete. Did I under--is that--

ANDREWS: Yes, that's not because there's a linkage between the three. It's just that's the goal that we chose for each one of them.

COHON: Okay.

ANDREWS: I just chose one number so I didn't have to show three numbers because they're all the same.

COHON: Okay. But, in fact, there may be a different--

ANDREWS: Yes. They're all the same number.

COHON: Okay, fine. Thank you.

KNOPMAN: Any further questions?

(No response.)

KNOPMAN: Okay. Thanks, Mike.

We'll move right along to Mark Peters who is going to give us an update on the scientific and technical investigations. Mark is the manager of Field Testing and EBS and Repository Design Support Office at Los Alamos.

PETERS: It's good to be back. Today, I'm going to give you all an update on the scientific and technical investigations. As a lead in, I'm going to be talking about data that we've collected to date. So, following Dr. Bullen's question this morning, this is information that will be incorporated into the Rev.00 AMR/PMR process. Following me after a long break that includes dinner and a good night's sleep, Jean will talk tomorrow morning on the plans from here out where we're feeding into the Rev.01 AMR/PMR process.

I'm covering several areas of testing that include natural systems, as well as the engineered system. Just as an overview, I've tied the testing program into the factors of the repository safety strategy and tying back to the presentations this morning by Abe and Mike Voegele. Factors related to the unsaturated zone, climate and the unsaturated zone. I'll give you an update on the bulkhead studies in the cross-drift, some updates on Alcove 1 and Alcove 7 in the ESF, a brief update on where we're at with the Chlorine-36 validation studies, as well as fluid inclusion work. A lot of this is just updating from what I told you at the end of June in Beatty.

The factors associated with impact of heat, coupled processes, a brief update on the drift scale test. This is brief. You did hear from Debbie Barr in Beatty with a more detailed presentation on the drift scale test. Then, to flow and transport below the repository horizon, colloid sorption, matrix diffusion, and there I'll take about Busted Butte. I'll focus here on an issue that the Board is very interested in on the applicability of the results at Busted Butte to underneath the repository horizon. That will be the main focus of that discussion.

To the saturated zone, give you an update on how we're integrating Nye County results into our saturated zone flow and transport model and also some preliminary conclusions from the SD-6 aquifer pump testing that we've just completed.

Then, getting into the engineered barrier focusing on again the performance of the drop shield waste package, an update on what's going on at the Atlas facility, the EBS pilot-scale testing, and then a couple of slides on where we're at with waste package materials testing. Joe Farmer will talk tomorrow about the waste package degradation PMR and he'll be on model validation so he can provide a lot of details, as well, on this particular testing program.

First, I'll start on the natural systems. This is a slide we've all seen before, I believe. It's just to get everybody oriented; the exploratory studies facility and the cross drift here in red with the potential repository block to the west of ESF. Today, I'll focus on results from Alcove

1 and Alcove 7, as well as some discussion of what's going on in the cross drift.

This is a blowup of the cross drift, in particular. Again, I'll talk some about Alcove 7 and the Ghost Dance Fault testing, Alcove 1 which is off the map up here. But, the important point here is this is the layout of the cross drift. It shows the proposed locations of the niches and alcoves in the cross drift. Jean will talk in the morning about the testing, the niche alcove testing, that we're starting construction on and we're planning for next fiscal year. I'm going to focus on the bulkhead studies. If you remember from June, we've installed two bulkheads in the cross drift; one about halfway down the cross drift at about 1750 meters and one at about 2500 meters just before the Solitario Canyon Fault. We've since closed those doors and this. So, we've isolated the back half of the cross drift from the ventilation system and we're sort of watching it return to ambient state.

Probably important to remember the cross drift exposes pretty much the major part of the Topopah Spring tuff. As we go down the cross drift from the start of the cross drift to right about here is all upper lithophysal. This will mean something to you all when I show some of the data. The middle nonlithophysal which would make up about upper 10 percent of the repository horizon is exposed from about here to about here. Then, we have lower lithophysal from here pretty much all the way down close to the Solitario Canyon Fault.

First the bulkhead studies, we're looking at flow and seepage processes in the repository host rocks. The first bulkhead is in about the middle of the lower lithophysal unit and again it goes all the way through including the isolated Solitario Canyon Fault zone. There's two bulkheads. We closed those doors in mid-June. So, we haven't been ventilating in there. We've got hydrologic instrumentation. Basically, every 25 meters, we have hydrologic instrumentation that's measuring water potential at two meters depth through the rock. And, again, we've isolated it from ventilation, but we do plan on entering in there approximately every two months. We just went in last week actually for a couple days. So, there, we break the ventilation, enter, do some maintenance on the instruments. We also do active geophysical measurements, neutron logging where we're looking at changes in water content and that requires somebody going in and actually putting something down borehole. The systematic instrumentation is hooked up by phone lines. So, that, we're collecting real time as we go. And, we're also going in and turning the head on the TBM as part of the TBM maintenance program.

This is some water potential data from the cross drift. This is water potential in -bars. So, dry is in this direction. So, as we get wetter, water potential would tend to go towards zero. So, for example, this is over 2400 meters from the start of the cross drift. Three dates plotted; December, April, and then recently here in August. A couple of things to note. You've seen the data through April at the last update. It's important to notice that early-on before we saw the effects of ventilation--I should back up and say this data is all from instruments that are two meters in the rock. So, it had yet to see the influence of ventilation at that time. So, in December, we saw relatively uniform, relatively high water potentials. Then, as we started to see the effects of ventilation even deep in the rock, this is primarily--you can just about pull out the geologic contents by looking at this data. I mentioned that the upper lith is in this area here. The middle non-lith which has a lot more longer through-going fractures, we're seeing drying along the fractures. So, that's why you're probably seeing drying due to ventilation. And, you get into the lower lith and you see much less effect of that. The lower lith has a much lower frequency of long through-going fractures.

This is data from a weather station, a temp to relative humidity station, that we have at the surface of the rock beyond the first bulkhead. I mention this rise right here in relative humidity is right after we closed those bulkheads. So, you can see that the environment behind the bulkheads has gone up to close to 100 percent relative humidity very quickly and the temperature tended to stabilize very quickly. Here, it looks like the first door--we had a problem with the second bulkhead door, but you can see the temperature is pretty uniform and the humidity has risen very quickly as compared to before when we were aware that we were getting influences of ventilation.

This is data from a heat dissipation probe just before the second bulkhead, three different depths. There's four holes here. We have instruments at 30 centimeters on up to 150 centimeters. Important point here is at great depth, we're already seeing the influence of ventilation before we closed the bulkheads. The purple right here is at 70 centimeters and we were starting to see some drying as we were at 30 centimeters depth, but you can see that there's a turn and we're starting to see rewetting here. So, that's the trend associated with the rock starting to rewet right when we closed the bulkheads right around the 23rd of June. So, this is the kind of information that we're collecting from those instruments that's allowing us to monitor how the drift's rewetting. And then, eventually, when we see likely spots where we might expect some drifts, we'll go in and install some drip cloth type collection systems like we have in Alcove 7 to try to collect drips if we see any. Right now, we don't expect to see anything in there. This is the kind of data that will give you a feel for the kind of data we'll collect.

Alcove 1, again the purpose of Alcove 1 is to look at infiltration and percolation through the Tiva Canyon through unsaturated welded tuffs. It's part of our "El Nino" testing where we're introducing a significant flux of water at the surface and then looking for how it travels through the fractured tuff, but also how seepage into the alcove below takes place. Phase 1 took place last fiscal year and we're in the process of doing Phase 2 right now. These are some of the basic statistics as of the end of August. We're again varying the application rates and I'll show you some data in a minute, but we've put about over 40,000 gallons of water on the top of the alcove and we saw seepage in Phase 2 much faster, in about three weeks; whereas in Phase 1 it took about, oh, close to two months to see the first drips into Alcove 1. In Phase 2, we saw it went faster. That was because the fractures had remained relatively saturated from the first phase of the experiment. And, again, this magic 10 percent number, as we've gone through Phase 1 and 2, 10 percent of the water that we've introduced we tend to see collecting in the alcove in the drip collection system.

This is just to remind everybody of the scale. For those who have been to the ESF, this is the hill going up above the--and you're about 30 meters from surface to the crown of Alcove 1. So, that's the scale of the experiment. And, the infiltration plot, this is a plan view showing the infiltration plot which is larger than the plan view of the alcove and the back end of the alcove.

Summation as of the end of August, plotted in blue is the cumulative amount of water in gallons through late August. Then, plotted in red is the cumulative amount of water collected in the alcove itself. So, that's the seepage volume.

Just to give you a feel, I mentioned that we're varying the volume. This is the flux per day that we're introducing at the top at the surface to collect in the alcove and you can see we're varying it over several factors here. The next slide is a real nice way of showing some of the interesting systematics. Again, the blue is just the applied water as a function of time. The red is the seepage water that we've collected in the alcove. A couple of interesting things to note, there's a little bit of a time delay here. When we increase the volume here, it took a couple of days for us to actually see the increase in the seepage volume in the alcove below. So, you see that delay and you see that throughout as we varied the infiltration rate with time. When the process is varied, remember that there's about 10 parts per million lithium bromide in the water that we're introducing. We're in the process of starting to change that concentration to see how that affects and then we'll start getting this better idea for fracture matrix interaction, the matrix diffusion processes in the Tiva Canyon.

Alcove 7, again that is the southern Ghost Dance Fault alcove. Here, it was another part of our so-called El Nino experiments there. We've installed some bulkheads where we've isolated the back half of the alcove that includes the Ghost Dance Fault and we were basically looking for seepage into the alcove near the Ghost Dance Fault. A couple of bullets on what we saw. As in the cross drift, the rock returned ambient conditions meaning greater than 99 percent humidity very quickly and we had not seen any drifts. We go in there periodically. We have a drip cloth collection system and we've yet to see any dripping water in that alcove.

Some preliminary data from the USGS. This is the interim heat dissipation probes. This is water potential again in bars versus station location. There's two bulkheads in this alcove. One is actually up here around Station 60. So, Station 0 starts at the ESF. So, the first bulkhead isn't even shown. These particular heat dissipation probes are at about 70 centimeters depth. So, they saw a tremendous amount of drying because, remember, in the ESF we'd been ventilating for quite while before we even installed these probes. In the case of Alcove 7, the first bulkhead is not doing a very good job of sealing. So, that's probably why we're still seeing some significant drying in the rock before the first bulkhead. The second bulkhead tends to seal things off a lot better. One thing we can say, we haven't seen any dripping water. Behind that second bulkhead, the water potentials are going up to very similar to what we saw in the cross drift in the sort of -1 bar range. We don't see any influence of the fault. I say that and then there's this one outlying data point, but we think we have an explanation for--the fact because it's showing dry water potentials, it probably is an artifact of not being in good contact with the rock. So, we're not seeing any drips. It's returning to pretty much ambient water potentials in Alcove 7, as well, despite the fact that the Ghost Dance Fault comes right through here.

Chorine-36 validation. In January, I told you we were about to start doing this. In June, we were in the process of drilling. I don't have a lot more to update you on. We've had some delays in the field, as well as working on some quality assurance and getting procedures together, etcetera, for the analyses. So, I don't have a whole lot more to tell you on this. But, just to refresh your memory, we are in the process of collecting samples at the Sundance Fault and the Drillhole Wash Fault structure and the ESF by drilling two to six meter long boreholes, mostly two meter long boreholes. This is again--these were two of the locations in the ESF where we saw apparent bomb pulse where June Fabryka-Martin and coworkers have found bomb pulse Chlorine-36. So, we're going in and we're conducting foundation experiments where we're taking core, analyzing for Chlorine-36 and also looking for tritium, technetium-99, and also doing some U series analyses. this is a cooperative study between the USGS, Livermore, and June is also analyzing some slits of the samples so that we have a good comparison.

We've completed 23 of the boreholes. More importantly, all of our procedures at the USGS, Livermore, and the Canadian group, AECL, are in place. Livermore is in the process of starting their analyses for Chlorine-36 and technetium-99 and USGS has done some water extractions and they're prepared to start doing tritium analyses and also AECL has begun. I'd like to say that at the next Board meeting we'll have some real data to show you all. I'll make that a goal.

Fluid inclusions. Again, to refresh your memory, there's a cooperative study with UNLV, DOE, primarily the USGS, and the State of Nevada, and here we're addressing the paleohydrology, the upflowing water issues, associated with whether some of the fracture minerals have been associated with upflowing or downward percolating water. We've done a lot of sampling. We had done a lot of sampling when I talked to you in June from the ESF and cross drift. We're having integrated workshops where all the participants are getting together and looking at samples together under a microscope. Right now, we're in the process of taking that sample suite and trying to focus on some of the key samples.

Some of the preliminary observations. There are fluid inclusions in some of these--it's primarily in the calcites that we're looking for the fluid inclusions in the fracture minerals. There are fluid inclusions that indicate relative high temperatures, 30 to 50 degrees C, a couple that maybe even have homogenization temperatures as high as 80C. The key is how old are they? What's their age? And, that's really what we're focusing on right now. Right now, preliminary observations of the USGS suggest that they're restricted to the older calcites and that's based on just a field observation. The USGS is in the process, as well as UNLV independently, of identifying cross-cutting opals and primarily they'll be able to use geochronology to try to really nail the age of those fluid inclusions. So, that's really going to be the big focus into '00 and this currently is planned for '00 to really go in and look at the geochronology in detail.

Drift scale test, I probably don't need to remind everybody what the purpose of that is. We're evaluating coupled processes at the field scale in repository horizon rocks, in the middle level lithophysal which is the upper 10 percent of the potential repository. A couple of bullets to refresh your memory, the heating phase data to date suggests that the heat transfer is conduction dominated. There is a key role being played by boiling and moisture moving around through convective processes. The pore water that's being mobilized by the heat is tending to move above the heated drift and then drains on each side. So, we're not ponding above the heated drift. We're actually draining and seeing wetting on each side below the heated drift. I think one important point here--I've got a plot that will address this

--is the coupled process phenomena. There's been a lot of discussion about boiling versus sub-boiling, but I think it's important to remember that some of the phenomena that we're looking at in terms of coupled processes will still occur even at sub-boiling temperatures and I think I've got some data and we'll get to that.

Just a refresher, there's probably no need to dwell on this, this is the way out of the drift scale test.

Status update, this is a plot you've seen before. Again, we're running at right around power shown in green. We're running it right around 185 kilowatts and this is the temperature profile for the representative drift wall temperature sensor. You can see some blips in here. We have had some power outages. We had a pretty long power outage actually, about four or five days, back in late June or early July. We were down for four or five days. But, some of these are actually scheduled power outages, but that's producing the blips in the temperature history, as well as the power. We're still moving forward towards a target of 200C at the drift wall, but we're in the processes of scoring--remember, we have the ability to turn--right now, we're at about 100 percent power on the wing heaters and 80 percent on the canisters. We have the ability to turn that power back to maintain that 200C. We're in the process of evaluating how we're going to go do that here probably within the next month or so.

Another temperature diagram. This particular diagram is two boreholes, horizontal boreholes, that run right above the plane of wing heaters. So, that's why you get this humped profile. This is just the same set of temperature sensors. So, this is the heated drift here, the power of each borehole, and you're just moving down borehole and this is just marching through time. I believe, Debbie showed some animations of these kind of temperatures last time. The humped profile is simply because the inner wing heaters are at lower power than the outer wing heaters. You can see the flattening as we went through local boiling at 96C and you've picked up the hump profile again and you can see the wing heaters where this is data through mid-August, I believe. You can see we're up above 200C close to the wing heaters. We're reaching a quasi-steady state here in the rock.

This gets into the point about coupled processes below boiling. Give me a minute to explain what's going on here. There's data from two boreholes shown here. They're both vertical boreholes from the heated drift. One is a temperature borehole that has RTD temperature sensors in it and then the other borehole is one of Livermore's electrical resistivity tomography boreholes where they're doing geophysics to monitor saturation changes. So, what I've plotted is I've plotted temperature in the temperature borehole versus saturation. Now, what's plotted in saturation space is we did baseline measurements. We did ambient measurements before we started the test. We continued to do active measurements as we're going along. So, I'm comparing the saturation at some point in time versus what it was at ambient. So, anything less than 1 would suggest drying, if that's clear. So, what we're showing-- maybe concentrate on one curve. This is data from three different days, but if you concentrate on the data for Day 511, you can see that at a given--along that borehole is a function of temperature. You're seeing actual decreases in saturation below boiling. So, it's going from roughly close to a ratio of 1 to ratios below .8. Then, you can see above where we might even get a change in slope and maybe additional significant drying. This was expected. You know, if you look at the steam tables as you go up in temperature, you expect more to go into the vapor and vapor pressure would increase. I guess, the important point is we're seeing pH phenomena at sub-boiling temperatures. Chemistry, we'll still see even at 60 or 70 degrees C, if you have water, it's hot water; so, you're still going to see chemical effects and there will still likely be mechanical effects. So, I guess the big message is there's still coupled process phenomena that we have to address as we go forward and incorporate information into performance assessment.

Busted Butte, just to refresh your memory on the purpose of Busted Butte, looking at flow and transport processes in the Calico Hills, you heard a lot about Phase 1 work at the last meeting. Paul Dixon gave you an update on that. Phase 1, we basically completed the field work and we're now primarily just continuing to inject in Phase 2. We continue to collect collection pads and we're in the process of doing the quantitative analysis in the lab.

Just to remind everybody where Phase 2 is, I'll emphasize Phase 1 which is the smaller scale experiments. Phase 2 is the large test block here. If you've been in the tunnel when you walk in, on the right hand side. So, this is where we're concentrating our fuel work right now and right now the plan would be to continue this injection collection analysis for the program into '00.

Probably, I want to spend more time on the issue that I know the Board is interested in which is the applicability to the potential repository block. It was discussed some at the last meeting and I've put together some slides that you can have a look at and maybe generate some discussion. Remember, Busted Butte test bed is primarily in a vitric, a glassy part of the subunit of the Calico Hills. Busted Butte is southeast of the repository block right about, let's say, eight--five or eight miles to the southeast of the repository block. Here, we're looking at a vitric subunit of the Calico Hills. We're evaluating fracture matrix interaction, matrix diffusion, and matrix dominated sorption. But, Calico Hills, it's not an analogue. It's actually a distal extension of the Calico Hills as exposed underneath the repository block. I also have a slide in here that will bring out the point. The Mineralogic-Petrologic model that we're using in ISM, the integrated site model, does provide a framework for us to look at the vitric/zeolitic distribution in the Calico under the repository block.

So, let me show a couple slides. This is a stratigraphic comparison. This is Borehole H-5 which is over on the west side of the repository block and the stratigraphic section as exposed to Busted Butte. This gets at my first point that this is really just a distal extension; it's not an analogue. You see a lot of similarities. You see a thick section of Calico Hills vitric; at H-5, you see a much thinner section, but still primarily vitric unit. The one thing that's missing at

Busted Butte is this fully zeolitized horizon or the partially zeolitized horizon, but you can see that this vitric and then in the vitric/zeolitic is exposed to Busted Butte as the distal extension of that formation.

Getting at the Min-Pet model and the representiveness, this is a slice out of the Mineralogic-Petrologic model from ISM. This is the ESF here just to get you oriented. Here is the ESF, there's the cross drift. So, the repository block is right in there. The color ski is percent to zeolites. Again, this is the top of the Calico Hills. So, it's the very top of the Calico Hills. So, you can see on the side here, the cutaway, it also shows the other parts of the Calico Hills. So, theoretically, I could just show a series of slides and it shows slices of the Calico. For purposes of this discussion, if you look at the overall average zeolite distribution in the whole Calico, it tends to be zeolitic in the upper half and vitric in the lower half. You can see also on here are these--excuse for the projection--but there is these lines, these sort of slanted lines. Those are actually for borehole control. So, these are the boreholes where we have input for the Min-Pet model. So, this is the kind of framework that we have to understand the vitric and zeolitic distribution in the Calico. Then, use the information from Busted Butte to incorporate that into the process model. So, this gives you a feel for the borehole coverage and how confident we might be in the distribution under repository block.

On to the saturated zone, we are in the process of incorporating data from the Nye County program. This gives you a list of some of the data that's being incorporated into the saturated zone flow and transport model. Looking at cuttings from their wells, incorporating lithologic data into the hydrogeologic framework model. We're also looking at the water-level data for far-field calibration. Looking at the pump test data. We've also taken some samples of alluvium and we're doing some laboratory sorption experiments at Los Alamos for these three key radionuclides to incorporate into the process model, as well as performance assessment. Then, we've collected some water samples and we're doing hydrochemistry, major cations and anions primarily again for calibrating the flow fields, and finally we've also done some Eh/pH measurements in some of the boreholes, as well, to address some solubility speciation issues for some of the key radionuclides; namely, technetium and neptunium are two of the important.

We're also working diligently to establish some processes and interfaces so that we can take the Nye County data, transfer it, control it, and allow for incorporation into our saturated zone Process Model Report. And, we're in the process of integrating and coordinating and working with Nye County for the next phases and Jean will talk a little bit about that tomorrow.

SD-6, I had mentioned in June that we had finally hit total depth on SD-6 and we were in the process of doing a pump test. These are some preliminary results from the USGS and studies there. We pumped the borehole for about two weeks. We were about 300 feet below the water table. That was our total depth. We were only able to pump at about 15.5 gallons per minute which was much less than we thought we would be pumping at. We drew the well down by about 163 feet and we were monitoring nearby boreholes to see if we could stress the aquifer in a more regional sense and we were unable to see any drawdown in any of the nearby holes. And, at first cut, a very preliminary conclusion would be the permeability of the water-bearing fractures that we encountered at the bottom of SD-6 was very low and any tranmissivity estimates that we're getting out of the test probably aren't representative of the primary fracture system. But, again, we met the testing requirement. We hit the water table and then went the additional 300 feet and were able to at least generate a reasonable pump test over two weeks.

Switching gears completely from the natural system over to the engineered system. We've talked about the Atlas testing, the pilot-scale testing that's going on in north Las Vegas. First, I'll talk about the test canister #1. That's where we were looking at Richard's Barrier that was originally conceived to support the LADS effort early-on, but we're continuing this test because we're also gaining valuable information on potential backfill materials. That test is continuing. Again, it's a Richard's Barrier. It's a core and with a medium sand over top of it and I'll show some pictures in a second. But, it's been going on since mid-December and we are dripping at superpluvial rates, a lot of water going on top of this Richard's Barrier. And, it continues to effectively re-divert the water and I'll show a plot that gets at that point in a second.

Just a reminder, this is about a meter and a half, a little under a meter and a half in diameter in the canister itself. It's about four meters long. There is a clear acrylic plastic tube that is sort of a mock waste canister and you have the coarse with the fine aggregate over top and there's instrumentation throughout the backfill. We're also weighing the tank and we're also weighing the breakthrough water and that's what gives us our mass balance on where the water is flowing through the system.

Just some pictures. This again is that acrylic-- that mock waste container and this is when we were in the process of putting the backfill into the system and here's the top of the fine after we were finished emplacing the backfills.

This shows some data as of pretty much the end of August. This is the water bounds for canister 1. So, we've got weight, the water in pounds versus time. The blue curve here is the weight of the water injected. The purple curve here called stored is the weight of the tank that basically that's the water that's being stored in the backfill. So, that's the change in the weight of the tank with time. And then, we've also plotted the breakthrough water. So, you can see what makes up this difference is primarily the water that's been diverted by the capillary barrier itself, the coarse/fine interface. So, that's being collected off the sides of the canister. So, the basic point here is that nearly 98 percent of the water is either diverted by the barrier or it's stored in the backfill. So, we've seen very little breakthrough.

Test canister 2 was a normal backfill. I talked about that last meeting. That only ran for about three to four weeks. So, I'm going to focus a little bit on canister 3 and that's in the process right now. Some things happening there. That's to look at processes in the EBS, but we've got a drip shield with a mock waste package. So, again, it's a drip shield. It's a two centimeter thick stainless. It's got a crushed tuff invert, no backfill. And, we're just in the process of starting the dripping. So, we heated with no drip shield from early June up until early last week. We then emplaced the drip shield and heated pretty much end of last week, over the weekend, and I haven't had a chance to check, but we were supposed to start dripping yesterday or today. So, we should be in the process of dripping onto that drip shield right now and then monitoring the interaction between the drip shield and the waste package and particularly focusing on whether we get any condensation on the underside of the drip shield and dripping out of the waste package.

This is again same scale. This is just a drawing of that test layout. I've got a test layout, I've got a picture of this that's more informative. This is again about a meter and a half in diameter. Here's the drip shield with the mock waste package. There's a five kilowatt, 5,000 watt, heater that runs down the axis of this mock waste package and then there's crushed tuff ballasted in the invert. And, again, there will be no backfill placed over the top of this. So, we'll be dripping in drip collection systems above the drip shield. And, Livermore, primarily, has done a whole series of predictions on what they expect to see here, much different conceptual models, and so it will be interesting to compare to what we actually see. We're in the process of--there's additional testing plan and Jean will get to that tomorrow and also talk a little bit more about canister 3.

This is data from canister 3. What we're doing is this is data from four different temperature sensors. This shows where the tests are coming from just to show you that we're maintaining the temperature of that mock waste canister at eight degrees C and the surface of the test canister itself is maintained at 60 degrees C and you can see the temperature in the invert is close to 65C, but this is data that we've been collecting since mid-June just as a baseline before we emplace the drip shield.

Switching gears now over to waste package materials, everybody understands the objective here is to confirm corrosion rates and the corrosion mechanisms for waste package and drip shield materials. So, the testing program that you heard about from Joe Farmer in June, you're going to hear more about tomorrow interims of model validation. That's ongoing. So, we're still addressing the key materials degradation issues. We're still looking at a wide range of test environments, varying the total solid content of J-13 all the way up to basically saturated J-13. So, anywhere from 10 times all the way up to saturated now, varying pHs, etcetera.

We are looking at localized corrosion testing in terms of crevice corrosion, as well as looking at the stability of the passive films and the influence of hydrogen pickup on the candidate materials, and we also are doing some interesting studies on the long-term stability of the passive films that develop on Alloy 22 and the titanium drip shield materials. Basically, by doing a lot of microstructural examination with atomic force microscopy to see--basically, you take a topographic map of the surface of the specimen so you can see how that passive film grows and what it's distribution is over the surface.

We're also looking at stress corrosion cracking. There, we're actually, you know, initiating cracks and looking at how they grow, looking at how the passive film interacts with the alloy. Then, finally, we're also doing some computer simulations, thermodynamic modeling of the long-term thermal stability in terms of the stability of Alloy 22 and how the impact of intermetallic phases and other phases might affect the long-term stability of Alloy 22.

That's a very quick overview of what they're doing at Livermore. Joe will probably touch on a lot of that in more detail tomorrow. That's it for my update.

KNOPMAN: Thank you, Mark.

Questions from the Board?

NELSON: Thanks for a lot of information, Mark. I've got a couple of questions for you and I'll just throw them out at you. I think the first that I have is water potential, it seems to not get to zero. What water potential would you expect? Is there a linkage? Does it have to get to zero before you have drips?

PETERS: You know what, you're asking a non-hydrologist and I believe it does not have to get to zero to see drips, but somebody--

NELSON: Is there a model for the prediction of where it has to be to get drips?

PETERS: Well, he's gone? He's outside.

NELSON: Okay. I'll ask him tomorrow. Can I ask you is there any air exchange evidenced through the rock mass? I'm trying to understand how much of it is air exchange. Maybe air exchange from the bulkheaded zones with outside through the rock mass?

PETERS: We grouted and we sealed with sodium silicate on each side of the bulkhead to try to minimize that. So, you're thinking two to five meters back through the fracture, rock mass, and around?

NELSON: Yeah, I'm wondering because you seem to say there is some evidence that there is some circulation like that. You get a barometric response, some sense of an air movement possible. Could be something like an air dilution rate, you know, if you put some gas in there. Maybe something like a dilution rate might be used to--

PETERS: But, the air moving through the mountain with--you'd see that just any--I mean, what we're primarily seeing is the effect of the ventilation from following it. The ventilation will mask that in my mind.

NELSON: Right. Well, except in the bulkheaded sections.

PETERS: Yeah, and there we're just going back to whatever--but, that air flow through the mountain is going to produce some kind of natural saturation level in the mountain. We're not communicating. We're not seeing any evidence behind the bulkhead of any communication through the rock mass other than what you would expect normally.

NELSON: Well, I actually suspected through the rock mass with the presence of the bulkhead and the openings that do communicate with the outside, you're going have some air exchange.

PETERS: But, we've actually seen real nice ceiling at that--that first bulkhead seems to provide a very--it's providing a really good seal. I'm sure there's going to be some impact, but talking to the USGS hydrologists, that first bulkhead, so far, seems to be sealing up pretty well. We're seeing very little--

NELSON: But, you do expect some permeability to the rock mass in which case there must be--

PETERS: Yeah, but I'm not sure we would be able to pick that up in the noise of what we're looking at.

NELSON: Okay. Just real fast, do you have a model for the Richard's Barrier such that it might be possible to use it to evaluate the effect of construction imperfections on performance?

PETERS: We have a performance model for the Richard's Barrier, yes. You mean constructability?

NELSON: Yes.

PETERS: It hasn't been addressed in detail because it's not being carried forward anymore as an option, if I'm answering the question. And, they've looked at some of that, I believe, during the LADS effort, but right now, the Richard's Barrier isn't being carried forward as an engineered barrier option. Right now, we're going with the drip shield so that we haven't really looked at the constructability issues in any more detail.

NELSON: Okay.

KNOPMAN: Dick?

PARIZEK: On the figure that shows the number of boreholes that penetrated the Calico Hills--it's Figure 32--how many white lines should I have counted? Some of them seem close together and then some of them are short and some are long. It's not only the pattern of zeolite immediately under the footprint, but also at different depths below the footprint. Are all implied there by the length or the height of the white bar?

PETERS: All those boreholes are boreholes that penetrate the Calico.

PARIZEK: Partway or all the way to the water table?

PETERS: Well, it varies.

PARIZEK: So, I guess part of this is what percentage of the rock mass would be zeolite from the footprint clear to the water table and some holes would tell us that and others would not?

PETERS: Exactly.

PARIZEK: So, how many holes are there all together? Do you feel good about saying spatially how zeolites vary under the footprint?

PETERS: I think we feel good about how we understand it sort of in a north-south direction because we've got boreholes here and boreholes along the ESF. Where we have a lack of borehole coverage is within the block here.

PARIZEK: That's kind of an important place to have some boreholes.

PETERS: It's also an important place not to have holes.

PARIZEK: But, extrapolating Busted Butte, say, results on the Calico Hills is sort of then problematic as to how relevant the data would be to this particular footprint area. The other question is will the program do anything about that? We heard the possibility you might do some Busted Butte type experiments. Is that in the thinking or not yet in the thinking or shouldn't we worry about it? Well, I think I'm worried about it because I don't know what's down there for rocks.

PETERS: Okay. Two points. It sounds like the issue--you come right to the issue in my opinion. It's not whether --Busted Butte isn't an analogue; it's distal extension. The issue is how well we understand what's under the block. I think it's subtle, but that's the issue. Right now, we don't have any plans to do any additional characterization of Calico.

PARIZEK: I guess, if the results over the Busted Butte experiment are siting, as they seem to be, then we want to know should we stay sited or should we get service by the extrapolation. So, I guess, the program has to really dig into that.

PETERS: Yes, the answer is we have to look into whether we can defend the dataset that we have and can we use the Busted Butte results or we have--or, you know, we have to look at options. I think that's something the program has to be able to do.

PARIZEK: All right. Now, SD-6 had a very low transmissivity value, but that doesn't imply that rocks around the footprint will have low values because the pneumatic data suggests high values in places.

PETERS: That's right.

PARIZEK: So, that's just saying at least it didn't hit any big fractures or big faults.

PETERS: That's right.

PARIZEK: So, that's neither here nor there, but it's useful.

PETERS: But, at the bottom there, we were in--we were well below, we were deep.

PARIZEK: Deep, okay. Yeah, then, on the water samples that are coming out of the heated experiments, I guess, you had going on, do we know anything about the chemistry of that water and we do know what minerals are being mobilized and where the minerals are going? I'm kind of interested in a couple of the papers that were given to me here by--I can't pronounce his name properly. It's the Walters papers dealing with silicate mobility.

PETERS: Right.

PARIZEK: And, it seems to be minor temperature changes moves a hell of a lot of silicate. And, here, you've got some temperatures at least in one of those places that you showed up that was 80 degrees Centigrade to 65 degrees Centigrade. That would be high enough to mobilize silicate, it would appear. Is there any data on that?

PETERS: Yeah, there's actually quite a bit. We're seeing variations in the pH, quite a bit of variation in the pH. When we see water that's truly not--we've got a problem. It's we're sampling water sometimes that's actually condensate that's condensing in the sampling tube. So, you've got to be careful. Other pHs get down below five, but that's, I think, easy to understand. pHs where we're collecting real water from the hole that's not condensing in the tube, the ambient pH in the middle non-lith is probably high sevens to above eight, and we're getting pHs below seven as the testing has continued as we've collected water. The dissolved solid content is a little less than J-13 in most cases, but we're seeing evidence of interaction with the fracture minerals, primarily calcite silica as it condenses and interacts with those minerals as it drains into the borehole.

I think Debbie talked last time about the influence of CO_2. We are seeing a CO_2 rich gas halo in front of the boiling front and that's probably driving a lot of the pH changes. I think there's probably a lot of calcite dissolution going on. There is some interaction with the opal in the fractures, but I couldn't pull the exact silica concentrations out of m head for you right now. But, we've got that information. That's available and we could get that.

PARIZEK: And, the drift scale heater experiment you showed last time or maybe Debbie did, the water movement--well, the water did move because it seemed like bluer on the cross-sectional diagrams that were shown by the wing heaters showing that water somehow got from the rock and got underneath it, but not whether it went by matrix or went through fractures. Is there anything new known about the mechanism of flow or whether it's going through fractures or matrix? It's redistributed moisture, but how does it get there?

PETERS: That's hard to tell with the geophysical methods that we have. We do know there's a lot of water flowing through the matrix based on the chemistry, but that's hard to--using the geophysical methods that we have, it's hard to tell whether it's fractures or matrix controlling that flow.

PARIZEK: Will Bo address that tomorrow to show us that he can model it?

PETERS: Well, you can model it if you do a permeability type conceptual model. Yeah, we modeled it. We did our predictions with equivalent continuum conceptual model and a DKM conceptual model and we clearly can reproduce where the moisture is moving if we use our DKM predictions.

PARIZEK: That's what I thought. We saw one diagram that showed the predicted versus observed and--

PETERS: Yeah. Yeah, I thought you meant the actual measurements because when I go out and do geophysics I can't tell you, oh, that pocket of water is moving through fractures or matrix, but I can tell you the overall water distribution is consistent with the dual permeability conceptual model. Maybe that answers it.

KNOPMAN: Okay. If I may, while you have this slide up, just jump in here with a question. Can you show us on this slide where H-5 is?

PETERS: I believe, it's down here.

KNOPMAN: Okay. Now, your scale goes--

PETERS: Maybe a little further south. It's down the south of the crest.

KNOPMAN: Okay. Okay. Your scale on that goes from zero to, what, 85--

PETERS: 85, yeah.

KNOPMAN: --percent. And, yet, I see about six boreholes in the repository block and I see a huge amount of variation. So, wherever you don't have data, you've just--it looks like you've just--I can't figure out how you could construct that kind of a--

PETERS: This is out of the integrated site model which --

KNOPMAN: I know, but wherever it comes from, I still don't see how you can blend those pretty colors when you don't have any data.

PETERS: This comes directly out of the framework model. We have points of data and then there's a--

KNOPMAN: From what?

PETERS: The data points are from the boreholes, and then in between those data gaps, you have a--

KNOPMAN: A what?

PETERS: A framework program, Earth Vision, commercially available that draws surfaces between those data points and provides a framework. It's used by petroleum companies, etcetera, for doing basin models, everything. It's just Earth Vision is a commercially available software package that uses geologic framework.

KNOPMAN: Yeah. No, I have no doubt you can use any number of interpolation models. I'm just trying to understand why you'd use one over another. What basis do you interpolate points when you have that few and then most of them seem to be, you know, along kind of a transect there. I don't know how you go laterally from those, I don't know what the basis is for the--

PETERS: Well, for example, you--

KNOPMAN: How do you interpolate it, extrapolate--

PETERS: Well, you also use somewhat your geologic knowledge. You know in these kind of set sequences that there's very rarely significant lateral thickness variations. Okay? You're extending away from the caldera in this direction. From here to there, you don't expect it to go from that thick up to that thick because you also have understanding of the overall geology of the area. So, you're using some sort of geologic reasoning to make sure that the output makes sense. You've got a surface geologic map and you've got exposures of the sections to also confirm that. So, I mean, as much as it might look like magic, I mean you've got a lot of other controls on it that allow you to make sure that it makes sense.

KNOPMAN: But, is it fair to say that there was some surprise involved when the cross drift was constructed as to where exactly the contacts were, and as a consequence, we now have a lot more of the repository in the lower lith than was imagined before the cross drift?

PETERS: Actually, if you go back--the results of those predictions versus what we actually saw were presented probably in January or maybe the meeting prior and the earlier version of the geologic framework model predicted where we thought we'd see the contacts. And, if you look at vertical, how far were we off vertical, it was within a couple meters. So, it depends on how bad you want to--I'd say that's pretty good.

KNOPMAN: Okay. I don't mean to be giving you a hard time. I'm just trying to figure it out as to how you infer from your existing base of knowledge to get what, I think, misleadingly shows a tremendous amount of detail and differentiation on a--that's just my view.

PETERS: What I wanted you all to understand here is this is our understanding and this is the data that we'll use to understand what the distribution is under the block. I think it was important for you to know that.

KNOPMAN: Okay. Alberto?

SAGÜÉS: So, really, there's only like about eight boreholes in the proposed repository footprint, roughly?

PETERS: There's none in the repository footprint except for SD-6. All the rest are outside the repository footprint, the block.

SAGÜÉS: Uh-huh. Okay. Maybe I cannot see the scale very well there. It would look like--are those inside the repository or--

PETERS: No, the repository is actually pretty--you can delineate the repository pretty much by those boreholes.

SAGÜÉS: Okay. So, then, really, the information inferred for the repository footprint comes from points that are--all of the data is coming from points outside the repository footprint?

PETERS: Just outside the block.

SAGÜÉS: Uh-huh. And, that particular color map has not taken into account information derived from the cross drift, right?

PETERS: Well, the cross drift doesn't get into the Calico.

SAGÜÉS: Okay.

PETERS: The cross drift is just to the Topopah. So, the Topopah data is in there, but that's stratigraphically above the sets up here in the cutaway.

SAGÜÉS: All right. Now, if you were to use a different commercial software program, would the--for example, that little white spot in the middle of the--

PETERS: I think they're all the same. Well, it's all basically the same interpolation scheme.

SAGÜÉS: I see, okay. The question I had originally--

KNOPMAN: Excuse me, Alberto, I'm sorry, but they're not all the same. You can choose many, many different models for interpolation that will give very different results.

PETERS: Okay.

KNOPMAN: Okay.

PETERS: Mark Tynan, did you want to add something?

TYNAN: I'm not tall enough. Can you hear me? I guess, it's fair to say that you are very correct. The only way we can determine beyond a reasonable doubt what the zeolite content of any part of the Calico is is to dig it out. So, what are the--how much do we have to do? And, there's a couple of observations that aren't perfectly clear from this. We did not have a summation of the percent of zeolites top to bottom through the Calico to present you. That probably would have been a little bit more enlightening.

But, two things that you do see about the Calico is the distribution of the zeolitized materials is more common towards the north and towards the east. And, as you go down through the section, at the base of the section, there's more zeolite; and at the very top, it appears to be there's a little bit more zeolite. The zeolite maps were constructed in a complex manner like everything else in the program, but it was done by essentially unit and they were done from available core data, the available geophysical data where you can tie the geophysics to the core, and then extrapolate it to a percent of zeolite based on the geophysical response, too. So, where we had core information added to that, you produce this.

If there's an infinite number of ways to present this information, I don't think that's wrong, but there's some limitations on how far we can go with the information that we have. But for a reasonable representation of the distribution of the zeolites by unit which is what they did within the Calico, it's fairly good. It's fairly representative to the extent that we can do that.

Now, whether or not, let's say, there's a fault that controls the zeolitization in the west from the north-south drift or something else, you really can't tell. But, are these rapid dropoffs, are they gradual? You know, the only way we can tell is to completely drill the area. But, ultimately, it probably doesn't make a big difference. I think you'd have to look at the total unit content of what it looks like and that's still to come another month or so down the road before we can discuss that in any detail.

KNOPMAN: Okay.

PETERS: It's really on how you handle the Calico in the PA, as well, in the process model of the PA; where you are in terms of conserved and bounding as to whether the information--it gets back to how much are we going to use Busted Butte information in the SR.

KNOPMAN: Okay. Again, I apologize for jumping on you about this, but it is a point that we've been puzzling about because there are important results that come out of Busted Butte, but they become less important or difficult to deal with if we don't understand what's going on in the repository block.

Priscilla?

SAGÜÉS: Excuse me, my original question was something different. But, really quickly, on the EBS pilot-scale testing in your Slide 39, what is the main objective of this? Surely, it's not to drip water on hot stainless steel by itself because, you know, a lot of that could be inferred from just steam properties and the like. Is it the backfill effect; what's the main objective?

PETERS: There's no backfill. Primarily, one of the big issues is to address whether you're going to get wetting in the invert and any condensation on the underside of the drip shield dripping onto the mock waste package. So, it's without backfill looking at the response of the drop shield as it drains and any potential condensation on the underside. The next test canister will be to--there will be backfill emplaced over top of the drip shield and that will be the next test that will be conducted. Similar dripping again. That will then overlay the impact of backfill.

SAGÜÉS: I see. So, it's really what comes from the effect of the crushed tuff and the like. Are they doing any modeling on this just based on--

PETERS: Yes, they're doing predictive model--let me back up. We're measuring properties of the crushed tuff, as we have with all the backfills in the lab and then they're also doing predictive modeling of the response to this using at least three or four different conceptual models and then comparing that to what they actually see.

KNOPMAN: Any further questions from the Board or the staff?

(No response.)

KNOPMAN: Dan, did you have a question?

BULLEN: Oh, no.

KNOPMAN: No, okay. Mark, thank you very much. It was an excellent overview of a lot of material in a short amount of time.

PETERS: You're welcome.

KNOPMAN: We're going to now turn to our public comment period in one minute. Just stand by.

(Pause.)

COHON: Sorry about that, but it's the curse of cell phones. You've all been there. If we didn't have them, we wouldn't have interruptions like this.

We have one person who signed up to speak. That's Walter who will pronounce his last name for me when he comes to the microphone. Walter? Sorry, I couldn't read your writing. If you could identify yourself?

MATYSKIELA: My name is Walter Matyskiela and I'm a consultant. I've been doing some work for the State of Nevada. I happened to hand Dr. Parizek a copy of a paper that I'd written a year or two ago which looked at a natural analogue for the most important physical process that the waste is going to impose on the mountain which is the heat. Most of what natural analogues people have talked about are relatively insignificant compared to what--have little to say about what the heat is going to do to the mountain and the fundamental issue is the silica mobility.

As we're aware, the mountain is 80 percent silica and it turns out most of the silica in the mountain is in a metastable state; in other words, it's not well crystallized.

It didn't crystallize slowly; it crystallized very rapidly. For example, the vitric gas is an extremely soluble silica mineral. The crystobolite which constitutes 10 percent of the Topopah Springs, for example, is extremely soluble. It has very high dissolution rates.

The paper that Dr. Parizek referred to looked at the effect of a small sill that was intruding into a tuff that was very similar to the Yucca Mountain tuff. In fact, one of the units there is the Paintbrush Tuff. It's a non-welded vitric tuff. But, there is also a devitrified tuff there and we looked at what the effect of the heat was on the silica minerals in the tuffs that were around the intrusion. We inferred that there was a significant amount of water moving in the fractures and the water carried some silica around and if we distributed it and put it in places where we might not want it to go, you were worried about isolating waste in the repository, for example.

Most recently--I've left some abstracts out in the table in front and outside in the hallway--we figured out how this happens if the silica minerals get so rapidly dissolved in the water that's moving. Everybody understands that the heat mobilizes the water out of the pores and it condenses somewhere. Most people, I think, initially, five years ago, would have told you that the water was going to just disappear. It was going to go away. Don't think about it anymore. That doesn't happen. What happens is it goes someplace where it's cooler and it condenses and then it trickles down. As it's trickling down the fractures, the connection between the pores and the tuff and the rapid movement of the water in the fracture allows the large surface area of the tuff pores to provide a huge dissolution surface for the silica minerals which have high dissolution rates, anyway.

So, essentially, what you do is you can saturate water with slowing in a fracture over a distance of about one meter. Start with distilled water, one meter down, that water is now completely saturated for whatever temperature it happens to be flowing at with silica which means that you're sucking silica out of the pores of the rock quite rapidly. So, you're going to deplete--you know, open up the pore sizes high up and you're going to move that silica somewhere down below the mountain, wherever it goes. But, if you really worried about adsorption, for example, of radionuclides below the repository--this would be one of your key isolation mechanisms--you really should think about what all that silica is going to do as it migrates downgradient and runs across cooler temperatures with saturated solutions of silica. I would guess that's probably going to come out a solution and coat most of those porous areas of the Calico Hills that you were just looking at for so long and make them unavailable for adsorption even if they were going to be available for adsorption to begin with.

So, I think there's some real issues about moving the silica around in the mountain because of the heat. This coupled process that most people have not paid much attention to, I think there's probably some reason that you ought to pay more attention to it.

And, my name is pronounced Matyskiela. I just wanted to stand up here and correct my name.

PARIZEK: Yeah, I apologize for not saying it.

MATYSKIELA: That's okay.

PARIZEK: You told me how to say it and I forgot. I apologize for that.

MATYSKIELA: Anyway, I'm done unless anybody has a question.

COHON: Thank you very much.

Are there any other comments or questions from anybody?

(No response.)

COHON: Anybody want to talk about the difference between SR and LA?

(No response.)

COHON: No? Okay. We stand adjourned for today. We'll reconvene tomorrow at 9:00 o'clock sharp. Thank you to all of our speakers and all of our participants. Thank you.

(Whereupon, the meeting was recessed, to reconvene 9:00 a.m. on Wednesday, September 15, 1999.)