UNITED STATES

NUCLEAR WASTE TECHNICAL REVIEW BOARD

***

FALL 1997 BOARD MEETING

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Hyatt Fair Lakes
1277 Fair Lakes Circle
Fairfax, Virginia 22033

Wednesday, October 22, 1997

The above-entitled matter commenced, pursuant to notice at 8:40 a.m.

BOARD MEMBERS:

JARED COHON, Chairman, NWTRB, Presiding
JOHN ARENDT
DANIEL BULLEN
NORMAN CHRISTENSEN, JR.
PAUL CRAIG
DEBRA KNOPMAN
PRISCILLA NELSON
RICHARD PARIZEK
ALBERTO SAGUES
JEFFREY WONG

STAFF:

PAULA ALFORD
WILLIAM D. BARNARD, Executive Director
MICHAEL CARROLL
SHERWOOD CHU
CARL DI BELLA
DANIEL FEHRINGER
LINDA HIATT
RUSSELL K. MCFARLAND
DANIEL METLAY
VICTOR PALCIAUSKAS
LEON REITER

ATTENDEES/PRESENTERS:

JACK BAILEY
LAKE BARRETT
JAMES BLINK
WILLIAM BOYLE
STEVE BROCOUM
PAUL CRAIG
GEORGE DANKO
THOMAS DOERING
PAUL HARRINGTON
LARRY HAYES
KLAUS KUHN

ATTENDEES/PRESENTERS: [continued]

DAN McKENZIE
CARL PETERSON
RICHARD SNELL
ABRAHAM VAN LUIK

P R O C E E D I N G S

[9:30 a.m.]

CHAIRMAN COHON: Good morning. My name is Jared Cohon. I'm the Chairman of the Nuclear Waste Technical Review Board. It's my pleasure to welcome you to the Board's annual Washington meeting. I have to note, of course, we are in Fairfax County, not Washington, D.C., but nevertheless this is our Washington meeting.

We used to have our Washington meetings in January, but our January meeting upcoming will be held in Amargosa Valley in Nye County, Nevada.

Let me make a disclosure at the outset. I'm from Cleveland. I grew up in Cleveland. So I'm feeling really on edge and very tired this morning. You won't even have to watch the games or read the newspaper. You'll be able to tell what happened the night before just by my mood each morning. We won't talk about last night.

I would like now to introduce to you each of the members of the Board. It's important that you know who we are, and I hope that you will take advantage of that knowledge during the breaks to interact with the Board members, get to know them, meet them for the first time, if appropriate, or reacquaint yourselves with them.

As I introduce you, colleagues, please raise your hands and turn towards the audience or otherwise make yourself known to them so they know who you are.

I want to emphasize that each of our members serves on a part-time basis. We all have full-time jobs. In some cases more than full time.

In my own case, I am president of Carnegie Mellon University. My own experience and expertise is in systems analysis techniques and their application to environmental problems, including nuclear waste.

John Arendt is a chemical engineer who retired from Oak Ridge to form his own firm. He specializes in many aspects of the nuclear fuel cycle of which standards and transportation are two examples. He chairs the Board's panel on the waste management system, and he'll be convening this afternoon's session on repository operations.

Daniel Bullen is in the Mechanical Engineering Department at Iowa State University where he specializes in nuclear engineering and in particular nuclear waste management. He chairs our panel on performance assessment and he'll be convening tomorrow morning's session on waste package design.

Norman Christensen is dean of the School of Environment at Duke University. He brings to the Board expertise in biology and ecology and he has had extensive experience in the management of large-scale and complex scientific projects with policy implications.

Paul Craig is professor emeritus of engineering at the University of California, Davis. He's a physicist by training with special expertise in research interests in energy policy issues especially as they relate to global environmental change.

Debra Knopman is director of the Center for Innovation and the Environment in Washington, a former deputy assistant secretary of Interior, a former scientist and science manager at the USGS, and an expert in groundwater hydrology. She chairs our panel on site characterization.

Priscilla Nelson is program director in the Directorate for Engineering of the National Science Foundation in Washington, a former professor at the University of Texas, and an expert in geotechnical engineering. She chairs our panel on the repository, and in that capacity she will be chairing this meeting, the focus of which is design.

Richard Parizek is professor of hydrologic sciences at Pennsylvania State University and an expert in geology and groundwater hydrology.

Albert Sagues is professor of civil and environmental engineer at the University of South Florida. He's an expert in materials and corrosion with a particular expertise in concrete and its behavior under extreme conditions. He will be convening tomorrow's session on waste package degradation.

Jeff Wong is chief of the Human and Ecological Risk Division of the Department of Toxic Substances Control of the California EPA in Sacramento. He's an expert in risk assessment and chairs our panel on environment, regulations and quality assurance.

The Board is supported by an outstanding staff. Many of them are here arrayed along that wall. I won't introduce them because most of you already know them, but I do want you to know that their continuity and their quality have been and continue to be invaluable in getting our new Board members up to speed and way up on the learning curve.

As usual, we have a very full agenda over today and half of tomorrow. As I mentioned already, it's focused on the repository and waste package design, which is one of the four elements of the viability assessment. It's also a vital component related to the other three elements of the VA.

In a moment I will be turning the meeting over to Dr. Nelson, but I do want to say a few things of an administrative nature and a substantive nature as well.

One is about the budget. The energy and water appropriations bill for fiscal year 1998 was passed by Congress and signed by the President just a few weeks ago.

It's a bill that contains funding for both this Board and for the Office of Civilian Radioactive Waste Management. OCRWM received $350 million, which is about 8 percent less than the amount in the President's request to Congress. I expect that Lake Barrett will be informing us shortly on this year's program in light of that shortfall in appropriations.

Similarly, the Board did not receive all of the funding it asked for. This means that we will have to adjust. We intend to have three meetings of the full Board in 1998 rather than four. We have moved to a smaller, less expensive office at Courthouse Plaza in Arlington. The Board will be reducing its staffing level somewhat. Fortunately, it appears that we can accomplish that on a voluntary basis.

There is no question that when the viability assessment is delivered there will be much to do by the Board to evaluate it. This meeting will focus on repository design, one of the four key elements of VA, as I mentioned. Future meetings will address other critical issues that affect the VA. For example, our January Board meeting will focus on saturated zone hydrology.

I want to say a few words about Board positions and Board pronouncements and member statements. The NWTRB, this Board, matters. What it says is taken seriously by policymakers and members of the public. The Board generally conveys its findings, conclusions and recommendations in writing in the form of formal reports, letters to Congress, and/or the secretary of DOE and/or the director of OCRWM, and in written congressional testimony.

Of course the Board consists of several members, individuals, each with his or her own style, each free to say whatever they choose. But comments by individual members, including me, are just that. Of course, on occasion, one of us, especially the chairman, will make statements on behalf of the Board, as I am right now, and in doing so I am speaking for the Board and you can take it as a Board position. Otherwise, when we make individual comments, they are no more than that.

Whether comments of Board member eventually become a Board position only time will tell, but of course a Board member's thinking is relevant. In effect, at these meetings, when we make statements and ask questions, we are thinking out loud as a Board. They do not represent positions unless we indicate so. They may be on their way to becoming positions which we will convey in writing.

To indicate to the DOE how the Board's thinking is evolving, we intend to begin giving relatively rapid feedback to the DOE following each of our meetings, perhaps in the form of letters to the program director. Such letters would give initial Board reactions to at least some of the key issues covered at the meetings. We are going to start this practice with this meeting.

A few more housekeeping and administrative announcements. First of all, we ask that all participants sign in, and, as you know, or least those of you who have been to prior meetings know, these meetings are on the record. So I ask that all speakers, Board members, presenters, anybody who is speaking here to identify themselves before they speak and to speak clearly into a microphone.

We will have a public comment period this afternoon at approximately 5:20, depending on when the scheduled sessions end, and tomorrow at approximately one o'clock, depending on when those sessions end. If you wish to comment during either of these times, please sign up at the registration table in the back and we will call on you at the appropriate time.

Each speaker will be limited to five minutes and only five minutes, but there is no limit on the length of written materials that may be submitted for the record, and we welcome such submissions.

Now, without further ado, I am pleased to introduce Priscilla Nelson.

DR. NELSON: Thank you, Jerry, and welcome to those who have come to our meeting, to Board members, to speakers, and of course to our consultants who I will introduce in a moment.

I want to begin this meeting by commenting on the focus. We will first heart project updates. Then we will move on into the meeting focus of the repository design operations and waste package design sessions.

Our meeting objective here is to gather information, enhance the Board understandings of the assumptions and the hypotheses under consideration or made by the DOE, focusing on data and models and processes, methods of analysis and their interpretation and how these various facets of the overall projects are fitting together into the viability assessment and will continue to be considered on into license application down the road.

We appreciate in particular all the conversations that we have had with project people, especially over the past few months, in preparation for setting up this meeting. There has been an awful lot of cooperation and we thank you very much.

We have a lot to cover. I will keep introductions generally to a minimum and ask all speakers to maintain their focus and make sure that we can set aside time for questions and answers because Board members always have lots of questions, and that is very important and valuable time for us to consider.

Moving right into the agenda, I would like to invite Lake Barrett to make a presentation. Lake is the acting director of the Office of Civil and Radioactive Waste Management, U.S. DOE, and he will tell us about the status and the 1998 outlook for the program leading to the viability assessment about this time next year.

Lake.

MR. BARRETT: Thank you very much, Priscilla. Good morning, members of the Board. I would like to make about ten minutes worth of general remarks. I believe the Board members should have the written statement. It will be available in the back in. And I will leave time for questions to the Board's content.

I would like to start off talking about the congressional and the status of the program and touch on design a little bit and talk about standards development, which is consistent with what the Board has been doing here in the session.

Congress has completed the work on the 1998 appropriations. We effectively received $346 million in FY-98. Congress stipulated that $12 million of the reduction should be taken in science activities at Yucca Mountain, $16 million be taken from other program management and other accounts not directly related to site characterization and interim storage. Of the remaining $6 million, $2 million was unspecified and $4 million was in the Nuclear Regulatory Commission's certification for the multi-purpose canister that President Clinton line item vetoed on last Friday.

The reductions in our 1998 budget affect ongoing and proposed scientific work related to the viability assessment at Yucca Mountain. These reductions are causing some delays in the schedule for collection of scientific data in several areas including that in the East-West drift.

We have been able, however, to sustain construction and the basic science construction activities in the East-West drift. The program direction cut affecting contractual services will adversely affect our validation of activities in the design features, concepts of operation, and refined cost estimates on these designs. Although the cuts are having an impact on the program, I firmly believe the program funding is adequate to complete a satisfactory viability assessment.

During 1997 the project has continued to make substantial progress in the investigation at Yucca Mountain. The majority of the project activities during the year were focused on providing the information needed in the viability assessment. These efforts have advanced our understanding of Yucca Mountain and provide a sound basis for completing the viability assessment this coming year.

The program continues to collect scientific information and, using the insight gained from our performance analyses, we are focusing on a testing strategy for key uncertainties. An example of our performance assessments have show that the seepage of water into the emplacement drifts to be significant to repository performance. To better understand this process, we have isolated niches in the underground facility to observe the presence or absence of water in the fracture system. We felt this was especially important with the upcoming predictions of an El Nino that we may have more rain in the Nevada area to see if we could pick up any of that in experiments.

Over the next two days we will discuss the progress we have made in our waste package design and repository design efforts. Although we are developing a workable reference design for the viability assessment, we consider design work to be work in progress. We are evaluating alternative design features and concepts and expect that alternatives will continue to be evaluated throughout the licensing, construction and operation period.

Our design strategy recognizes the need for a workable reference design as well as the reality that technological advances can be expected over the decades of repository operation. We are preserving flexibility to ensure the design features identified now as possible alternatives, as well as those that may emerge with advancements in technology, can be accommodated in any future repository.

Since we published our last performance assessment in 1995, we have continued to conduct informal site performance assessments on a regular basis to help us manage the ongoing science and engineering activities. Our recent efforts have focuses on developing the foundation for the total system performance assessment for the viability assessment.

In 1998, the year that we are in now, we expect this to be a particular important one for the program as we complete the viability assessment, as directed by the President and the Congress. Presentations over the next two days will focus on the project activities leading to the viability assessment. I intend to use my time just talking about from my perspective the strategic significance of what we are going to be doing.

One of the foremost challenges in a complex, first-of-a-kind endeavor is to converge on a working concept and to define the additional information required to implement that concept. The viability assessment is a management tool that accomplishes this for the geologic disposal program. It's completion will culminate a three-year effort by the program to assemble the information collected during the site characterization into a workable repository concept for Yucca Mountain and to focus the program on the key remaining technical uncertainties.

The program has shared its plans for the viability assessment with the Board and with other interested parties over the last year. Much of the attention has been appropriately focused on the design, the performance assessment, and the supporting science activities. We recognize that the products associated with these efforts will not be sufficient for licensing.

Their completion, however, will help integrate the ongoing activities and help guide the completion of the characterization efforts by identifying areas where additional scientific or technical work is required to evaluate the site or to prepare a complete defensible license application for the Nuclear Regulatory Commission.

We have previously noted that the completion of the viability assessment will give all parties a clearer understanding of the information gained over the past years and the remaining work required to support national decisions on geologic disposal at Yucca Mountain. The license application plan will describe this additional work and provide an estimate of its cost. The plan will identify the work necessary to complete the site recommendation process and prepare the license application within the cost and schedule constraints imposed by an ever-tightening federal budgetary situation.

General agreement between the program and its overseers and regulators on this remaining work is central to the continuation of the geologic disposal program. We would appreciate the Board's views on this effort to ensure that we have identified tests and activities that are appropriate for the task at hand and that can be conducted within the constraints of the program.

Yesterday the Board held a panel meeting regarding the performance standards for a repository at Yucca Mountain. The regulatory standards for a geologic repository have been the subject of much debate since the beginning of this program. It would be timely for the Board to examine the issues associated with the standard and provide its views and insights. I would like to provide a few thoughts on those regulatory standards from my perspective.

Our revised program plan recognized the need to update the regulatory framework for the repository to reflect the policy changes since the enactment of the Nuclear Waste Policy Act, the realities of the budget constraints on the program, and, in particular, the understanding gained in more than 15 years of site investigations here at Yucca Mountain and also across the world. I understand you even have speakers from other countries as well, which I think is very important to get a global view of what is going on, because there are many similarities in the various programs.

We have considered these factors in the proposed amendments to our siting guidelines. It is similarly important that these factors be considered by the EPA and the NRC, respectively, in developing radiation protection standards and revising the licensing criteria for a repository at Yucca Mountain.

The Department believes that the regulatory framework for the repository should focus on issues central to protecting public health and safety and be implementable in a contentious licensing environment. That is, demonstrating compliance with the standards should not require a degree of proof that is beyond what science and engineering can reasonably provide. The National Academy of Sciences' report and subsequent discussions regarding the Yucca Mountain standard indicate that the level of protection provided by the repository standard should be commensurate with existing facilities.

We certainly agree that future generations should be afforded the same protection as current populations.

This standard, however, will be applied to estimates of repository performance over thousands of years in the future, which will involve an unprecedented level of uncertainty. Much of this uncertainty is irreducible within the bounds of a rational site characterization program and approach to design. Consequently, the regulations associated with repository development must maintain a degree of flexibility to accommodate the inherent uncertainty in the results of site characterization and performance assessment. The Board's views regarding the acceptability of this residual uncertainty will be significant to the rulemaking process and to the subsequent national decisions on geologic disposal.

Yesterday's discussions addressed the biosphere assumptions that the Department will use to evaluate repository performance. Many of the key issues associated with the repository standard relate to these biosphere assumptions that provide the context in which to evaluate repository performance. Since the future behavior of society cannot be predicted with scientific certainty, these assumptions are ultimately policy decisions.

We agree with the National Academy of Sciences that these assumptions should be defined in a rulemaking process. We must be careful to define reasonable assumptions because they are central to the implementability of the standard. We believe that the biosphere assumptions should be based on current conditions surrounding Yucca Mountain and not speculation about future populations or other regulatory precedents.

It is incumbent upon all knowledgeable participants in this process to ensure that the regulatory framework for the repository provides a reasonable basis to assess whether a Yucca Mountain repository will adequately protect the public health and safety and not be constructed so as to defeat the nation's policy on geologic disposal.

The program is continuing to implement the revised program plan and looks forward to completing the viability assessment this fiscal year. This milestone is important to the nation's geologic disposal program and will represent the culmination of a significant effort by all our program participants. We intend that this assessment will provide an unbiased, technically sound analysis of a Yucca Mountain repository. We look forward to the Board's review of this effort.

In the management area, I believe you are aware that Mr. Barnes left his position as project manager last month. I have appointed Dr. Dyer to be the acting project manager and Ms. Susan Jones to be the acting deputy project manager. Unfortunately, Russ could not be here today and Susan was stricken with an illness, and she will not be able to be here. Dr. Brocoum will carry that on very ably for us at the project.

Regarding the future, I intend to stay the course in the Yucca Mountain area while we concentrate on completing the viability assessment documents. TRW has recently announced a restructured organization to increase their focus on the underground postclosure aspects of the viability assessment while being able to adequately respond to surface preclosure issues such as surface facility, storage, transportation, and waste acceptance issues.

I expect that I will make some minor adjustments to the federal structure to reflect the change in policy setting for the program and the evolving nature of our work. I expect these changes will complement but not mirror the TRW changes.

Unfortunately, I also expect to implement a reduction in force of approximately 20 percent in our headquarters element next spring in response to the congressional direction which we received in our 1998 budget. However, despite these actions, I remain confident in our ability to meet the program milestones that have stated we will do.

That is sort of the end of my remarks, and I will be pleased to answer any questions or enter discussions the Board would like.

DR. NELSON: Thank you very much.

Are there any questions from the Board?

Jerry.

CHAIRMAN COHON: First, let me say, Mr. Barrett, that I was impressed by the way you characterized VA. I think that is just right and I think it is setting up VA to be just what it should be, the management tool that you describe. I have several specific questions. Let me say them all, and then you can respond as you like.

One is whether the President offered a reason for the line item veto of the multipurpose canister design money for NRC.

Two, why a 20 percent reduction in force is prompted by something like an 8 or 10 percent reduction in appropriations.

You didn't mention in your remarks, but it is in your written statement, something about the legislation, and also the lawsuit. If you could say something about those two things.

MR. BARRETT: The 1998 appropriations law, now that it is signed by the President, specified $16 million -- or is $14 million? I get those two reversed -- in program direction lines, which includes federal salaries. It also had language that went on and said that the Congress expects our office to meet the secretary's strategic alignment numbers for FY-98. We briefed the Congress to what those were.

For total federal staff today we have 201 people, 114 in the Forrestal and 87 out in Las Vegas, at Yucca Mountain project. The SAI target for the end of FY-98 is 173. That is 20-some-odd folks. Given that the focus is on the viability assessment, I do not want to adversely impact job one, which is a credible viability assessment. I am somehow going to take those hits in the Forrestal Building. If you take nominally two dozen people out of 114, it comes out to 20-some-odd percent.

It's in the Forrestal. I must preserve the essential aspects of the program, and that's the viability assessment at Yucca Mountain. We may have onesie, twosies reductions at Yucca Mountain. We are in the midst of a buyout. We have offered buyouts, and we have to see how this will all go. We have had all-hands meetings with all our staff as to what that is.

The line item veto. There is a process. For each bill the President sets up a criteria with Mr. Raines in OMB as to how to apply the line item veto properly in accordance with the line item veto law and looking ahead at all the various complications that go with line item veto, constitutionality, et cetera.

It starts off with what is in the bill that the

President didn't ask for and then goes through criteria: it benefits a small segment of population; it's an unwarranted corporate subsidy. This item was automatically on the list and it went through various culling within the Administration, and it was on the final list of eight items that the President line item vetoed.

It was considered an unwarranted corporate subsidy, I think is the quote that was in the President's statement. Basically that came down to a situation where the NRC is set up under its statutes to recover. They would charge the people who are asking for things. What the costs are would be reviewed for all canisters, be they single purpose, dual purpose, or multipurpose, which is tri-purpose. The costs would be recovered by the NRC and there was no need to have a direct government payment to the NRC out of our DOE money.

I'll make no bones about it. I tried to preserve that $4 million for the program. I am told by my CFO that I am probably not going to have the money. So it's effectively the $346 million. We felt very firmly and made the arguments not that I was against this being done by the NRC, because the multipurpose canister is a valuable thing and it will do that in a market-driven way.

The way that finally came out, money going to the NRC for all the vendors to use, was not destabilizing, did not create an unequal playing field for the various vendors in a market-driven approach, but that $4 million would have been better utilized supporting the scientific and engineering work that the Board is immersed in at Yucca Mountain, and that's where the money belonged. Unfortunately, I wasn't able to get it, but I'm still looking.

What was the third one?

CHAIRMAN COHON: What's happening in Congress and also the lawsuit.

MR. BARRETT: The lawsuit is in court. The oral arguments were on the 25th of September. People stated their cases. We presented our defense. Under the statute, we cannot select an interim storage site. The linkage is fairly clear. I think we have been through that. The court asked hard questions of all the parties, as judges should do, and they are considering what they are going to do and when they are going to do it, and I have no idea when that is going to be. You will have people say it's months away and some will say it's weeks away.

The legislative action. We all know S.104 passed last spring, two votes shy of a veto override. It was introduced in the House. We testified, et cetera. It passed the Commerce Committee in the House. I think it was a 42 to 3 vote.

Then it was referred to Transportation and Natural Resources committees. The transportation Committee passed it with a letter; the Natural Resources Committee held a markup on it. They reported it out unfavorably but did report it out, which allows floor action to happen. Now the Rules Committee needs to establish what the rules for that bill would be for the floor. That may happen any day now from the Rules Committee. Congress has stated their intent to go out on recess on November 7, two weeks from Friday. Many people believe the bill will come to the floor and will pass the floor before the House adjourns.

Then it needs to go back to the Senate. Depending on what changes are introduced by the managers of the bill on the floor in the House of Representatives -- I expect there will be changes. If it looks very much like the Senate bill, then they may not have to do a conference. The Senate could pick up.

If it remains in its current form, then there would probably be a conference and it will follow the due process. That would probably happen when the Congress returns in January or February, because I don't believe there is time if they really want to go out on November 7. That will be what that will be. The Administration's position has been clear and has not changed regarding the bill.

DR. NELSON: Any other questions from the Board?

[No response.]

DR. NELSON: Thank you very much.

MR. BARRETT: You're welcome.

DR. NELSON: We will move on to our next speaker. Presentation to be made by Steve Brocoum, assistant manager for licensing at the Yucca Mountain Site Characterization Project Office. Steve will be telling us about the fiscal year 1998 activities, the activities related to the ECRB, the enhanced characterization of the repository block, and other project office activities.

Good morning, Steve.

MR. BROCOUM: I will be presenting the Yucca Mountain project updates. If you look at this package, it has 29 viewgraphs. I'm actually going to talk to about half of them. The rest you can read at your leisure.

[Slide.]

MR. BROCOUM: Some of the topics that we will be covering today include the components of the viability assessment, design and scientific testing, the enhanced characterization of the repository block, and plutonium migration.

[Slide.]

MR. BROCOUM: First, about the viability. You are going to hear a lot about the design today. So I'll just very quickly make a few points.

It's a performance driven design.

The design is constantly evolving from today through the LA.

The priorities for FY-98 and for the VA are those systems with no regulatory precedence, the kind of things that fall into the bin 3 category. Some of them are listed here. That is where the focus of the design effort will be this year in getting ready for the VA. In other words, we are focusing on things that impact particularly the postclosure performance.

[Slide.]

MR. BROCOUM: We have a board called the Consultant Sub-board that reports to the M&O, consisting of experts in various fields to help guide us and give us advice on the design.

That board is focusing on the waste package design and fabrication, the waste package material and waste form degradation. A very important topic. This is one of the two key areas that really drives the performance of the repository according to the PA sensitivity studies.

Surface facilities function and design.

The met twice, recently, at the end of September, and they will be meeting two or three times during fiscal year 1998.

[Slide.]

MR. BROCOUM: I will now jump to page 8. The previous pages have a whole series of issues being looked at in design. Those issues will be addressed. This is the bar that addresses all those 21 issues listed. They will all be addressed satisfactorily for the VA design by the end of June of next year.

For all the four VA design products we are producing management plans. The very first thing that we are producing this year will tell us who is doing what, who is reviewing what, what all the schedules are, what the outlines of the documents are, so we know up front exactly where we are heading for the following year.

The design development draft will be done by 6/98 and it will be completed for viability assessment by 8/98. Not much time when you look at these schedules.

Basically, all the work of the viability assessment has to be done in the next to eight or so months. There isn't really much time to go out and do new tests or go out and collect new data to feed into the VA. Any tests and data we collect for the VA are of a confirmatory nature and of course will be included in the license application.

[Slide.]

MR. BROCOUM: With regard to the TSPA, we are focusing on model development and documentation. We are trying to get uniform databases and input to be used by all computer modelers. This is part of making our document traceable and transparent.

The TSPA this year is going under a QA program. In the past, science programs and design products have been under QA. TSPA has not. This year it is going under a QA program.

We are trying to use multiple lines of evidence to provide reality checks for modeling.

Of course, we have an independent peer review. We got a report from them. I think it was in July. We are trying to consider their comments for the VA, and they will have a second report July of 1998.

The real purpose of this peer review is to give us an improved TSPA for LA, but where we can incorporate their comments on the TSPA-VA, we will.

[Slide.]

MR. BROCOUM: This schedule reinforces my major point that all the work is occurring this fall and early spring. If you look at these bars, you will see the various chapters that make up the PA all in draft form by February 1998. You will also note that the base case calculation is completed by January of 1998. So really the VA is coming together this fall and early next spring.

Again, we complete the draft in 6/98; the final

TSPA 8/98; and then we only have a month to get it through the whole system and get it out of DOE, which includes printing, editing, all the review cycles it must go through. Under secretaries have to approve it and all those things. So we have a very tight schedule, but we have tried to buy as much time for the technical people to do their work.

[Slide.]

MR. BROCOUM: The license application plan is a very important component of VA, because this is going to tell the NRC and the Congress and the rest of the world exactly what needs to be done to get to an LA. It will basically describe what we are going to do for the major milestones in products that are coming up: the EIS, the site recommendation, license application.

It will explain why that work is necessary and why it will be sufficient, in our opinion, and it will give us a schedule, and it will provide the cost between the VA and the LA.

[Slide.]

MR. BROCOUM: We also have a management plan for the TSPA. We will have three iterations through the year of the LA plan for review. The final iteration will produce the final plan which will come out in 7/98.

[Slide.]

MR. BROCOUM: I am skipping a page here and jumping to page 14.

The MGDS-VA cost estimates. We have broken the periods into what we call development evaluation, engineering and construction, emplacement, caretaker, closure and decommissioning.

We will have the costs. They will be reviewed. There is a management plan. There will be independent review by Foster Wheeler, and that review starts this month.

[Slide.]

MR. BROCOUM: I am jumping to page 16. This shows a schedule of the management plan, the various steps to get there. The final VA estimate 6/98; the report will come out in 7/98.

So all four of the reports are coming out July or August of 1998. They are kind of coming together at the same time. The management challenge is to keep them all integrated, all consistent with each other, minimize any discontinuities among them, and that kind of thing. I think from a management perspective it's a big challenge this year.

[Slide.]

MR. BROCOUM: I will move on now to design and scientific testing.

The key attributes in our latest incarnation of the famous waste container isolation strategy, which we are going to rename, are these four:

Limited water contacting the waste packages.

Containment -- the longer the better.

Once the containment is breached, a slow rate of radionuclide release.

Then, once released, the dilution of the radionuclides during transport.

[Slide.]

MR. BROCOUM: The next few pages describe the hypotheses, which I am not going to show. I want to jump to page 19 because I want to talk about a couple of testing programs we have put in place this year. I want to talk about the first two in the upper left, limited water contacting waste packages.

We are making some changes in alcove 7. We are installing bulkheads to bulkhead off the Ghost Dance fault and then to bulkhead off a section of alcove 7 that is not in the Ghost Dance fault. We have an El Nino year coming up. So we want to see if we can see any infiltration, any differences between a faulted area and a non-faulted area. We also bulkheaded off alcove 1 above the PTN -- this is below the PTN -- and doing that.

We have two niches that are bulkheaded off now. We will have two more. So in a sense we will have a total of seven bulkheaded off niches to help us understand percolation flux, infiltration into the drifts, the second important parameters in the performance of the repository. So those are big efforts this year.

[Slide.]

MR. BROCOUM: I want to move on to the status of the enhanced characterization effort, which includes, of course, the East-West drift, several boreholes, labs, tracer tests and heater tests. I will talk about some of the those.

[Slide.]

MR. BROCOUM: The East-West drift. This is the schedule. I need to preface that the 1998 plan has not been baselined yet. It will not be baselined until about mid-November. So I think these dates are reasonably accurate, but they could move a little bit.

Basically, we are doing design. The launch chamber excavation starts in December of 1997. That is almost the same date that we are due to start the drift scale heater test. That is due to start December 8. So we have a lot of interface issues of concern here, because they are going to cut off the north ramp for a period of time as they construct a launch chamber and all the scientists will have to go in from the south; the power, of course, will be uninterrupted because we are just starting up a test. A lot of issues there.

The actual excavation of the East-West drift starts in March, completes just as the VA is coming out the door, in a sense, and then there will be some alcove excavation in the East-West drift following that which will be completed early in calendar year 1999.

[Slide.]

MR. BROCOUM: Some of the other parts of the enhanced characterization include SD-11, I believe to the north. One is to the north and one is to the south. All now in fiscal year 1999. Part of the cutback that Lake mentioned was taken by moving the boreholes out. These two boreholes will be moved out, and also reducing the design efforts in bins 1 and 2 versus bin 3.

We will also have a southern testing complex for studying the saturated zone. The exact siting hasn't been decided, but that will be a cooperative effort among the engineers, the PA people and the scientists. That all starts in fiscal year 1999 also. So all of these elements are in fiscal year 1999 and later. Had we got that $30 million, we would have considered moving some of these up.

[Slide.]

MR. BROCOUM: Another issue that has come up lately is plutonium migration from the Benham event. I think in 1968 there was a nuclear explosion below the water table. I think it's 1,600 meters away from that event.

There was also another one here, in Tybo, in 1975. They have interfered with this. There are a lot of issues here.

I think the migration if 50 meters a year. I'm not sure.

[Slide.]

MR. BROCOUM: The next few viewgraphs have a lot of detail. There are just a couple of points I want to make on these viewgraphs.

First, we recognize the potential for transport of colloids. The early site characterization plan, we had plans in there. Since 1988 we have been doing various laboratory and field studies to understand the formation of colloids and to understand their transport. We are also doing modeling to see how we can incorporate colloids into the TSPA. That's the major point of that viewgraph.

[Slide.]

MR. BROCOUM: We are doing additional work from now out to license application both on modeling and in field work on the Busted Butte. We will be starting that experiment, which is our first detailed look at transport in the Calico Hills. It includes colloid transport.

[Slide.]

MR. BROCOUM: The next few viewgraphs give you a look at the next three months. I will not put them up. As you can see, there are a lot of milestones coming up in the next few months as we go into the VA year.

[Slide.]

MR. BROCOUM: My final few comments here. We have less than 12 months. It is already the 22nd of October. October is gone. We basically have 11 months. We really have eight to ten months on the outside to get this together. So we really have to focus. We don't have time for distractions this year.

Last year we had lots of distractions. I'm looking at the record here. We don't need too many changes in requests; we don't need too many added experiments; we don't need much added. We have our hands full getting this done and getting the East-West drift done and keeping the program moving, I think. It will take all our efforts to get this done.

Our focus will be good science and engineering for the foundation of those products. We are trying to produce a product that is uncolored, that tells it like it is. That's the key thing, tells it like it is. We are going to lay out the science, lay out the engineering, lay out the performance. That's our goal, to make it in a way that is readable and understandable.

We have 15 years of information. We have to assemble that into a coherent repository concept, how that will perform, what more work needs to be done, and what it will cost. That is our fundamental job.

We had a strategic planning off site a week or two weeks ago and Lake told me my major job this year was to get this VA out and everything else is secondary. If I have competing things on my desk, all the competing things are swept off to get this VA out.

Thank you.

DR. NELSON: Thank you, Steve.

Let me ask you one question to start off the discussion. There has been a lot of discussion about various alternatives and enhancements. To what extent are they going to be included in VA, in all parts of the VA, the idea of the various engineering enhancements?

[Slide.]

MR. BROCOUM: The engineers will talk about that. There is a reference design and options. Those will be included. There is also program enhancements that the program is considering that are not in the baseline program yet. I will turn that over to Lake to answer that question.

MR. BARRETT: I assume the question is to the drip shields and ceramics and coatings and those sort of design options. When you use the words options and enhancements, there are all kinds of definitions. What jargon would you like to use here?

DR. NELSON: That's fair enough for you to define it the way you did and answer that one. Will those be carried on through for all four parts of the VA? Will they be included in cost?

MR. BARRETT: Yes. For example, backfill is one of the design alternatives. So we will have a reference design. We are not sure yet, but right now it does not have backfill in it. We will examine if we were to backfill, what does that mean? We would describe what does backfill do as far as cost, what does backfill do as far as performance, and is it doable from an engineering point of view.

The degree of detail and specificity on options will not be as much as the reference case, but it will be enough that you can look at it. An analogy would be, here is your basic Chevrolet car. It doesn't come with, say, power door locks. If you want power door locks, here's what it does for you and here is how much it costs. We can look at that. The Congress, the President, the Board, others can look at that and say that option obviously is worth that money, or that option obviously is not. That's a value judgment call. But we will try to present that information.

We recognize that there are lots of evolving things and we may learn other options as we go through, because it's a very dynamic environment.

DR. NELSON: So there will be a treatment by performance assessment for these options as well?

MR. BARRETT: Yes.

MR. BROCOUM: We have already done some assessments on various options.

DR. NELSON: Any other questions?

Dan.

DR. BULLEN: In your MGDS VA design product development status viewgraph, which was number 8, you talk about the documents that have come out. As we review the VA, one of the things that is very important for us to understand are the underlying assumptions that went into all the calculations that were necessary. You mentioned that these are now coming under a quality program. Could you tell me which of the documents that are listed in viewgraph 8 that have been completed are under your quality program and how easily traceable are those underlying assumptions?

In essence, I am asking you to help guide us in our understanding of what assumptions were made during the course of your completion of these documents.

[Slide.]

MR. BROCOUM: That's a perfect question to bounce off to Younker.

Is it design or the TSPA you want to talk about?

DR. BULLEN: It's number 8. Is that the one you've got up there?

MR. BROCOUM: Yes.

DR. BULLEN: Those documents were done previous to when you are coming into quality?

MR. BROCOUM: No. Design has been under a quality program for years. So everything that they do is under a quality program. The PA is what is going under QA right now. So I would assume that all the products that are going to come out for QA will be quality products. This is it. Remember, they are either the base case calculation or chapters for the TSPA-VA.

I'm looking at Jean here for confirmation. So they will be quality products.

DR. BULLEN: So our ability to determine the assumptions that underlie all the calculations will be very easy is what you are telling me.

MR. BROCOUM: It will be there. We'll make it as easy as we can. That's the goal.

In yesterday's meeting we made some comments on that and we visited with recently. It took them four years to go from where they were four years ago, which was not traceable, to where they are today. We see this as kind of a dry run for our TSPA-LA, if we get to that point. By then I think we could tell you it's truly traceable and easy to trace and all of that. This is the stuff on the way.

MR. BARRETT: We are using the word "quality." What we are talking about here is Nuclear Regulatory Commission quality assurance, documentation and pedigree. If it's not under, let's say, the quality requirements, it does not necessarily mean it's a non-quality piece of work. When we through the word "quality" around, that's a complicated word. Thank you.

MR. HAYES: Larry Hayes, M&O. Steve, would you put that slide back on?

MR. BROCOUM: The TSPA one?

[Slide.]

MR. HAYES: I'm sort of following up, Lake, what you just said. I didn't want to leave people with the wrong impression. If you look at the products there, the UZ transport chapter, UZ flow chapter, all of that work was done under a quality program; all of that work is documented under a quality program. I just wanted to make that point.

MR. BARRETT: That doesn't necessarily mean that it's easily traceable. It's all there; it's still complicated stuff.

MR. BROCOUM: All the stuff was done under science is under a quality program. That's the point Larry is trying to make. The same with other areas here.

DR. NELSON: Dr. Knopman.

DR. KNOPMAN: I have three questions.

You said, for all practical purposes, any new information that comes down the pike over the next 12 months will not be incorporated into VA but will be used in a confirmatory setting. Can you explain how VA will express that process?

For example, as crossing construction proceeds as some of the creation comes about. How would you be able to take that newly acquired data and respond to it in a confirmatory nature in VA? Will there be a separate chapter with the heading Confirmatory Testing?

MR. BROCOUM: I can't give you a clear answer, but let me give you kind of a vision. If the new data that comes in is within the bounds of what is in the distribution of the current data, say, for a particular parameter, well, it's the same, and you don't make any changes; you just keep going.

Let's say we get into the west end of the block, in Solitario Canyon fault, and we see percolation or water or something that is different than what we have seen before. That is outside. At that point we have got to decide, how do we handle this, because it's something we haven't seen before. If it's in August, for example -- that's when we get into that end of the block -- I really don't see how we can handle it given the schedule for VA at that point in time, because we already probably at the press. We may be able to handle that in some other document, an overview or something. If, God forbid, we delay VA, possibly we could handle it.

But there is a reality here. We are not going to get to the west end of the block until August or that time frame, and that is where you are most likely, in my view, to find new information.

Basically, if the information is within the current bounds of current information, it's confirmatory. If it's outside, we pause and see how we handle it. We don't ignore it, but I'm not exactly sure how we can handle it. It depends on scheduling.

DR. NELSON: Let me just say one thing. You mentioned that if you get some information that tends to be confirmatory that you wouldn't necessarily worry about it, but in fact I would encourage to really include that in whatever way you include the material that is less confirmatory. The way it's being assessed through PA it's very important to have that.

MR. BROCOUM: Both of you have made a good point. We will think about how to do that, reserve a section that we write at the very last minute to say, hey, this is late breaking news. We do that in the progress report. We kind of a late breaking, up-front section, I believe. Maybe we can do that here.

DR. KNOPMAN: Second question. I can't see on your charts where the overview chapter or executive summary or the pull-it-all-together chapter gets written.

MR. BROCOUM: Which overview chapter?

DR. KNOPMAN: For VA.

MR. BROCOUM: The VA will consists of the four products. Each of the products will have an executive summary. There will not be for the VA itself an overall executive summary or chapter.

Is that correct, Lake?

MR. BARRETT: That's correct.

DR. KNOPMAN: Third and last question. Since one of the products of VA is the license application plan, you will have a timetable there for products to support LA. When at this point are you assuming a suitability determination will be made and when, backing up from that date, will be sort of the close date on new information that would go into suitability?

MR. BROCOUM: The current baseline schedule for suitability is in the year 2001. I think it's in the middle of the year.

MR. BARRETT: License application is 302. This is published in our program plans. That's where this is. 701 is the site recommendation. There is various technical work that leads up to those things. There is no cutoff date. If the day before the Secretary is to recommend to the President we find something new, we will deal with that and we will deal with it properly. So there is no magic cutoff date.

DR. KNOPMAN: So you will have a comparable situation you have now with VA, where essentially 10 months before the document comes out you have kind of put the lid on further study.

MR. BARRETT: It is very similar to what you will see with the VA. We have a 5,000 node work plan schedule that we have on the master computer and it's available to your staff to see, all the various feeds and all the technical work in the laboratory and where it all flows together.

Steve was showing you what we have for the viability assessment, and there is a very similar network, not to the same specificity, for what you would have for the site recommendation and also for the LA. Some of the long lead time LA things are being done now. Some have already been done, volcanism, et cetera. It's all in there, but there is no magic cutoff date.

I don't want a misperception. Schedule is important; quality is more important than schedule. If Steve says, look, I am driving this using this schedule, still we will do quality first on this, and if something happens, we will deal with it.

If the schedule has to slide to make an accurate portrayal of what the situation is, how good and how bad Yucca Mountain is, I will delay it; I will not put an improper quality document that disregards something. But you always know there is always something coming up every single day; there is new information. There is not a cutoff per se.

We have had lots of debates. We do this as soft of like a yearbook supplement of late breaking information and how to deal with it, but I would not propose to the Secretary a viability assessment that does not address things appropriately. It doesn't mean every single experimental data has to be in, but you certainly have to use a lot of judgment and balancing to go with it.

MR. BROCOUM: We will submit an initial LA; we will update the LA. We've got a conformance confirmation program and they'll be getting new information. You would hope you would get no surprises, but you don't really know. The more information you have, the less likely a surprise. Again, that remains to be seen.

DR. NELSON: Jerry.

CHAIRMAN COHON: You said early on in your presentation that the design will continue to evolve until LA. This is in the same spirit as Dr. Knopman's questions.

I'm just trying to understand the realities of the next several months when you have got to focus on VA, quite appropriately.

With regard to design, effectively are we talking about there will be basically a pause in the continued development of that design for several months until VA is done?

MR. BROCOUM: There will be handoff from the design people for the things that are important for the PA to the PA people so they can do their base case. That handoff is occurring between now and November, and from November to January the PA people do their base case. Then they can go back and do some sensitivity studies, and anything new in design can be plugged in then. That's how the process works. They don't really pause. They pull the stuff together and hand it off and they just keep going.

CHAIRMAN COHON: Whatever they have in November is what gets handed off but the design people continue to develop.

MR. BROCOUM: Right. They are trying to focus on the things up front that TSPA is very sensitive to so they can hand it off so the PA people can do their work.

CHAIRMAN COHON: I understand.

MR. BROCOUM: They have worked very closely in planning all this all this year to do that.

CHAIRMAN COHON: So again you've got that kind of delicate management problem of finding yourself in August or September with design having evolved further.

MR. BROCOUM: Right. It will evolve in areas that don't impact the PA work. It's Dick's job to manage that and Jean's job on the PA side to manage that interface. It's very difficult and it's very realistic.

CHAIRMAN COHON: You skipped over it, but I would like nevertheless to ask you about it, and that's slide 18 with the hypotheses.

[Slide.]

CHAIRMAN COHON: I'm not asking that you go through each one in detail. I guess I'm trying to understand this slide in the context of the VA. This is the hypotheses with which we currently are working but they may change post-VA?

MR. BROCOUM: Right now Younker is working on the revision to the waste containment isolation strategy. That revision will be out in the middle of November.

CHAIRMAN COHON: You say you are going to change the name of that, by the way?

MR. BROCOUM: Yes.

CHAIRMAN COHON: What's it going to be called?

MR. BROCOUM: I don't know. We haven't decided yet.

[Laughter.]

MR. BROCOUM: We've got to decide among ourselves. Probably a safety case with some name.

CHAIRMAN COHON: Okay.

MR. BROCOUM: It will revise one more time during the year. I think next July or August it comes out again. So that's another thing we want to keep in track with all the other work we are doing. So these may not be the exact hypotheses that come out in November. We are working on that right now. We just had an issue resolution meeting on that.

CHAIRMAN COHON: The next slide was the design and scientific testing programs that you did show us, which are tied to those hypotheses.

MR. BROCOUM: Yes.

CHAIRMAN COHON: You may have said this and I might have missed it, but are all these ongoing or planned or in some cases completed?

[Slide.]

MR. BROCOUM: They are all in our baseline plan.

CHAIRMAN COHON: VA may identify additional testing programs not on this slide; is that correct?

MR. BROCOUM: That's possible, and this is not a complete list of tests; these are only some of them. Then you would have to implement those tests and the information in those tests would probably go into TSPA-LA.

CHAIRMAN COHON: Finally, with apologies. Everything you said about plutonium just went by me much too quickly for me to have gotten anything out of that. I don't believe we are going to be hearing about that during the course of this meeting. Yet it's a timely issue. Can we go back over this?

MR. BROCOUM: I would like to ask Larry Hayes to say a few words on that. It's under his area. He can talk about it a lot better than I can.

MR. HAYES: Larry Hayes, M&O. Specifically, what would you like me to address?

CHAIRMAN COHON: What's the issue? Why did you bring it up?

MR. BROCOUM: Because Los Alamos issued a paper, I think in July, on some work they had been doing. Previous to that, we knew they were doing the work, but it was all classified. They issued this paper in July and it hit the press. A big deal. Plutonium is moving 50 meters a year, whatever the distance is. A lot of interest. The point I was trying to make here is that we know about it, it didn't surprise, we had been working on it for years; Los Alamos has done a lot work on it for us. We are continuing to work on two key aspects, how they form and how they move.

I don't know if Larry wants to say anything else.

That was point I was trying to make.

MR. HAYES: We've considerable work ongoing in looking at colloidal formation stability in both the unsaturated zone and saturated zone. Some of what we are seeing, for example, would show that the charge on the colloids are more important in retarding transport rather than the size. We have looked at some water from J-13 and we find very small amounts of colloids.

In our plans for our new southern tracer tests we are going to try to design some experiments to where maybe on a relatively larger scale than we have been working at we can say something more definitive about colloidal movement.

The problem, as you probably are aware, is that we can latch on to something like plutonium, very long lived, and move it through the environment through these colloidal attachments, and we would like to be able to get better field information to put into our models to be able to more accurately predict whether that is a real problem or not.

There are a number of things being done at the test site on colloidal plutonium primarily that we are trying to latch into. What they are going to do at the test site we're not certain. It's frankly very difficult to do some of the experiments they would like to do, and we are still discussing with them what would be the best thing to do combining their resources and our resources.

We also have our Busted Butte test plan. That's an analogue site where we will go into Busted Butte, conduct the testing facility, and try in that area to also get some field information on colloidal movement.

CHAIRMAN COHON: Thank you.

DR. NELSON: We are just about of time. Dan, you want one question?

DR. BULLEN: One quick question. This may not be the appropriate place to answer it because we are going to talk about the enhanced characterization of the repository block later. I did raise an issue in the June meeting with respect to the potential adverse effects of the location and position of the East-West drift. I was just wondering what the status was of any evaluation you might be doing to address that.

MR. BROCOUM: We brought the expert with us that will address that. Is Peter Hastings here? He's in the back of the room. I'm not sure if this the right time or it comes up later.

DR. BULLEN: ECRB is later on the agenda.

MR. BROCOUM: The actual expert, the person who is responsible for evaluation is here. We guessed you might ask that question.

DR. BULLEN: I didn't want to disappoint you.

DR. NELSON: Thank you, Steve.

I want to make this transition right now. We have scheduled this morning's session just continuing because we started at 9:30 and we are going to be finishing at about noon. If people want to take a break, they'll have to take on of their own.

Thank you very much, Lake and Steve, for the overview, the update on the project. We are going to move into a sequence of sessions that are really geared towards presenting information on the repository. We will have presentations on the underground portion of the repository, the repository thermal management, engineered barrier system, and alternative repository concepts.

I would like to take this opportunity as we make the transition from the overview mode to hearing more about specific issues related to repository to introduce three consultants that the Board has invited to be in attendance to develop a resource for us as we embark upon this very fast track VA process.

The first person I would like to identify -- they are right behind me. If they could stand up and acknowledge who they are, let everyone see. The first person is Dr. Carl Peterson. Carl is professor emeritus of mechanical engineering from MIT. He's an outstanding, even notorious mechanical engineer with many, many ideas. His work has been widely applied, including in underground construction.

He's a first-time consultant to the board, and we welcome Carl and appreciate his efforts here.

The second consultant I would like to introduce is Dr. Klaus Kuhn, who has participated in several Board meetings in the past and has hosted the Board on visits to the German geologic repository for high level radioactive waste and spent fuel. Dr. Kuhn has served in a number of senior positions in the German nuclear waste program in his 30 years on the project, and we welcome him.

Thirdly, I would like to introduce Dr. George Danko, who is a professor in the Mining Engineering Department at the Mackie School of Mines at the University of Nevada in Reno. Dr. Danko has also participated in a number of Board meetings in the past, and he first served with the Board in 1992 and has several times since, offering contributions understanding and encouraging evaluation of repository ventilation, a topic we will hear about today. He has also worked directly with DOE subcontractors. We welcome him to our meeting. Thank you, George.

The purpose of the sequence of sessions is to get information out for the Board to understand the assumptions data on models, processes and analyses, hypotheses made, rationale behind the assumptions, and come to an understanding of the uncertainties that remain, those that may or may not be addressable before VA, those that may or may not be addressable as we move on toward suitable and license applications in the future.

We have a very full agenda over the next day and a half. Generally this is constructed to be overview, more information probably present in the transparencies that can be delved into in depth in the discussions here, but we really can't use these meetings as the detailed critique of technical issues and the close dialogue.

We will look, however, towards looking closely at any deliverables produced in the next 11 months in particular leading up to VA, be they draft or final, and to continuing conversations and meetings that the Board is going to be holding through their panel or smaller group discussions and interactions with DOE people. We appreciate DOE's participation and trying to keep that information flow going.

I would like to move on at this point between now and our noon lunch break. We have invited Richard Snell to give us a presentation on the repository layout, design, construction sequence for waste emplacement in the underground repository. Richard Snell is the manager of engineering and integration operations with the M&O contractor.

MR. SNELL: Good morning. I'm Dick Snell. I'm the manager of engineering and integration for the M&O at

Yucca Mountain project.

[Slide.]

MR. SNELL: This is a presentation on repository layout, design, construction sequence/waste emplacement. It is an overview type of presentation. The way the agenda is structured, it's in response to questions that have been asked.

The information that is being presented to you is coming to you kind of in short, snappy doses on various aspects of design. As we go through the program, it may seem to be a bit fragmented, but I think as we move through the whole agenda you will get the full picture. This presentation is indeed an overview.

I might comment in follow-up to a couple of the questions that were asked earlier about how we respond to changes. One somewhat positive aspect about what we are doing in the design is that a lot of the interest is concentrated in a relatively small portion or concentrated area of the design, namely, the emplacement drift, the waste package, and things related to it.

Because we get new information as we go forward does not mean that we necessarily upset the entire arrangement or overall approach to the repository design. The changes in many cases will tend to be highly focused. So we will be able to accept new information in those areas fairly readily, and I expect we will be able to respond to those reasonably well.

[Slide.]

MR. SNELL: We are going to talk a little bit about the controlling design assumptions or factors that we have, the layout, some of the excavation and emplacement sequences that we are anticipating right now.

I'll talk a little bit about the ECRB cross-drift and how it interfaces with the repository, or would, and you will hear more about that later in the program as well.

[Slide.]

MR. SNELL: The first topic is the design assumptions and the decision process and the analyses that we are doing in siting the repository and deciding its overall features.

[Slide.]

MR. SNELL: This is kind of a long list of those things that influence the repository design.

The geologic setting, of course. By that I will include not only the physical setting but there are climatic effects, as you all know, which have a major bearing on what we are doing.

The waste inventory heat output is a major factor, and the thermal loading that we select for the repository has a major bearing on the arrangement.

Physical characteristics of the waste package.

The transport and handling system for the waste package.

A desire to use mechanical excavation methods for developing the repository itself.

Drainage controls for the postclosure in the event that we have water in the repository.

Something about the performance confirmation program requirements.

And something also on retrievability requirements, which is part of what we are tasked with.

[Slide.]

MR. SNELL: We will talk a little bit about layout first.

[Slide.]

MR. SNELL: Some of the major siting considerations for the repository.

In 10 CFR 960, one of the stipulations is that we maintain a 200 meter minimum cover over the emplacement areas, earth cover or rock cover.

We need to be located above the saturated zone. This is also out of 960.

The minimum of 100 meters above the saturated zone is a design assumption listed here, but it's based on expectations on water table rise or unsaturated zone rise over geologic time periods. The information that is available to us in the system right now suggests about 100 meters is the maximum rise that one would expect to see in the saturated zone in any climatic variation and geologic time period variation.

We need to avoid major faults to the extent that that is practical, partly based on guidance from the NRC and also prudence from a design standpoint.

We are going to use the Topopah Springs welded unit, TSw2, as the notation here. That's the geologic unit that has been selected, given these other considerations and other factors in design, as the most suitable for location of the repository host horizon.

[Slide.]

MR. SNELL: This is a picture of repository siting area. This is not the repository footprint itself but it's the siting area. It's referred to as available upper repository because in earlier designs we had shown a repository with both an upper and a lower section. With some changes that we have made that I will talk about we do not now need the lower section of the repository. So what we are showing you is the upper portion. The lower section would be over in this area here.

There are several pieces of information on here that are relevant. I mentioned some of the criteria. There is a 200 meter cover limit, and it's outlined; it's noted here on the chart.

There are some major faults on the western side, a Solitario Canyon fault and a Solitario Canyon splay fault. Both seem to represent perimeter limits for us for this primary area.

In the north, up in this area here, there is what appears to be either a fairly steep hydrologic gradient or a rise or a higher location, if you will, in the saturated zone. We want to maintain 100 meters as a minimum over the saturated zone. So that tends to be a limitation on the north.

There are some faulted areas that are shown that go into the repository, but based on the exploration that has been so far, those do not seem to be features that are significant enough to preclude the use of this land for emplacement areas, but they are identified here nonetheless.

Those generally are the translation of those criteria into the footprint of the overall repository area.

[Slide.]

MR. SNELL: This doesn't show very well on the overhead. It probably shows better on your handouts. The actual repository footprint starts right about in here and ends right about here. So there is some usable real estate to the north and to the south if we should need it.

The current exploratory studies facility is portrayed here on the diagram. It's hard for me to read, but it generally comes in this way.

The ESF north-south main drift is about at the eastern boundary of the repository. Again, we are working up towards to the Solitario Canyon fault and splay fault on the left. There is about a 60 meter standoff from that fault right now.

With some design changes that have been incorporated, I am referring to a modification in how the ventilation is being handled, ventilation drift, and also some improvements in the way the emplacement drifts would be constructed which reduces the amount of space needed for what is called a launch chamber for the mining equipment. We get more effective emplacement space out of each drift. Right now these emplacement drifts go all the way across this area, and they are about 1,000 meters long. We can start the tunnel boring operations and use a little bit less space on either side. The net result is that we don't need quite as large a footprint for the repository.

What we are using here in this emplacement area leaves us with probably somewhere between 10 and 20 percent expansion capacity over what is currently identified. We are talking about 70,000 metric tons of waste to be emplaced, and I am suggesting that if we had to we could probably put in a little bit more in this same footprint, or if we get into areas where we have some difficulty using some of this area, we have some additional space that is available to us as a reserve, if you will.

[Slide.]

MR. SNELL: I have flipped this around. For the same orientation, it would appear like this if you compare it to the other charts, but it's easier to read the notations this way.

Here again is the exploratory studies facility that we now have.

As it is presently envisioned, there will be an emplacement exhaust shaft located in the northern portion of the area that we have tentatively selected.

There is an intake shaft for ventilation air for development purposes: mining on the south.

The emplacement drifts run all the way across from the east main to the west main. The way the repository is laid out there would be an exhaust main located under the primary footprint, running the full length of the footprint. Those exhaust mains were on the perimeters. By putting them underneath, that helps to reduce the amount of space that is required for pure construction purposes and improves the utilization for emplacement purposes.

You see for reference here the Ghost Dance fault.

In prior presentations we have talked about it. I think you will hear a little more about the thermal test alcove or drift scale test, the one that is going to start in December that Steve Brocoum mentioned. That is located right here. This is the alcove where that thermal testing will be started in December.

There are some other alcoves for testing purposes shown here. Here they intercept or come close to the Ghost Dance fault, which is relatively modest in character. By that I mean it's not the sort of structural separation that Solitario Canyon seems to be based on some drilling and testing that has been done in these alcoves.

There is a cross sectional cut that is shown here. If you take a cut through this footprint and imagine you are standing down there at the emplacement horizon, looking from the south to the north -- one other thing I will mention here. I mentioned there was expansion room to the south. We have shown an expansion area here. There is somewhat more available.

There is an emplacement exhaust shaft to the north. If there should be a collective decision to expand to the north, that decision would need to be made fairly timely because that exhaust shaft would need to be moved further north as well. So it's a decision that one would like to make fairly early in the sequence of things.

[Slide.]

MR. SNELL: Going back to the section, if we are looking south to north, this is kind of what you would see in the repository. There is a lot of nomenclature on both these charts, by the way. The coding for those is indicated here on this cross section. What these refer to principally is that the layers that exist in the TSw2 stratigraphy were put down over a period of time. There are references here to non-lithophysal and lithophysal zones. There is a lower, a middle and an upper. That's why you have all these various gradations.

The cross section of the repository as we currently envision it starts, as I say, about 60 meters just to the east of the Solitario Canyon fault, runs across through the stratigraphy. As you can see, it's sloped down from the west to the east. It terminates west of Ghost Dance fault.

The area we formerly identified for the lower repository block is down in this area. As I said, that is still available to us for expansion purposes if we should need it or choose to use it.

We have indicated here the top of the saturated zone. That is referred to here as the groundwater surface. The line indicating about a 100 meter water table rise and the 200 meter cover limit and the surface profile are shown here as well.

That gives you some feeling for what for what the cross section would look like.

[Slide.]

MR. SNELL: I'm going to go through these fairly quickly. I am looking at about 11:15 on timing here, and that should work fine. I will talk a little bit about the construction sequence as we currently envision it.

[Slide.]

DR. NELSON: Dick, this is probably the last time we are going to be able to really get a look at this until the VA document comes out. So if you want a few more minutes in order to be able to go through it the way you had planned, go ahead.

MR. SNELL: You steer me any way you wish. I can go faster or slower at your option.

This is the current exploratory studies facility. As it's currently envisioned, the development would begin coming off the south ramp. We would start with a large tunnel boring machine that would begin excavating a perimeter drift. That's about a 7.6 meter tunnel boring machine as we currently envision it.

You can start with tunnel boring machines of a smaller diameter excavating these drifts here. The expectation is that we would use two of the smaller diameter tunnel boring machines. Those are the 5.5 meter diameter that is associated with emplacement drifting.

What this shows is one is completed and you have got a machine here and a machine here with work in progress.

The planning right now suggests that a single tunnel boring machine for the 5.5 meter drifts could be sufficient, but two does offer some advantages in construction timing. So we are showing two at this time.

[Slide.]

MR. SNELL: This is a little bit later in the development. The large perimeter drift around the repository will have been excavated. Those three early cross drifts have been excavated, and excavation has begun on the north end with emplacement drifts.

Excavation will have begun under the primary horizon here starting on the ventilation drift that is going to go underneath the repository horizon.

[Slide.]

MR. SNELL: The ventilation drift under the repository footprint will have been completed at this stage. A group of emplacement drifts have been completed here on the north end.

This chart is identified as the start of simultaneous emplacement and development, which is the current expectation.

You need a substantial separation between waste emplacement areas and development or mining areas. That is what we will have. The judgment here is that to initiate emplacement you need four or five emplacement drifts available to you.

We expect we may have to do some mix and match on the wastes that come to the repository. So having a group of four or five drifts open at one time and the ability to use any one or all of them as you begin waste emplacement is what dictated this. The separation on the emplacement side and the development side I will show you on a later chart.

At this point you could begin. The underground development is probably 10 percent or so complete in terms of the overall quantity of excavation.

[Slide.]

MR. SNELL: This is a view of where you might be in year ten. In other words, ten years after you have initiated emplacement operations. It's progressing to the south, as you can see.

The sequence is that as you complete a group of mined drifts you can move a bulkhead that exists between the two areas, between emplacement and development area. You can move that bulkhead to the south, reestablish the ventilation separations, and then open up additional drifts for emplacement purposes, moving in this direction here.

[Slide.]

MR. SNELL: A similar picture here in 15 years, progressing from north to south.

[Slide.]

MR. SNELL: At this point, in a caretaker phase. That is, you have got all the waste emplaced, no more active mining operations, and you are at point now where you are simply monitoring the facility.

[Slide.]

MR. SNELL: A little bit closer look now at some of the ventilation considerations for the repository as we now envision them.

Same orientation, north at the left of your picture. There is an emplacement area exhaust shaft at the north with exhaust fans there. The system has about a 600,000 cfm capacity.

Intake is at the north portal, that is, the north portal of the current ESF, if you will. Air comes in through that north ramp and is circulated through the facility, is collected in the exhaust duct underneath the emplacement area, and then exhausted out that shaft.

There is a bulkhead separation shown here.

To the south, in the development areas where emplacement is ongoing, you will see notes here about a road header here, which is the machinery that is used to open up the start of an emplacement drift and give the tunnel boring machine a straight heading that it can work on. That is one of the changes that allowed us to use a little bit more of the space.

We have got a road header initiating a drift here and two tunnel boring machines at work moving across, building a new emplacement drift.

That whole area from the bulkhead south operates under a separate ventilation system. In this case it's a push system with the duct here on the south. Outside air is brought into the system, circulated through the development areas and exhausted out the south ramp of the current ESF. That also is about a 600,000 cfm capacity system.

[Slide.]

MR. SNELL: This is kind of a mindblower when you first look at it because of the way it's portrayed. You have to study it for a while to understand it. These numbers are year of emplacement.

At the north end of the facility, or over here on the picture, it tracks the expected emplacement as you go through the life of the facility, starting in the year 2010, which is what the current program plan calls for, and then moving all the way out with the last of the waste being emplaced in the year 2033 out on the south, about a 23 year emplacement period.

There is one glitch on this chart that I will mention. We show a standby drift here, which is just that. It's for standby purposes. These cross-block drifts are ventilation drifts. One of these cross-block drifts should be identified also as a standby drift. We really need three ventilation drifts going across the block.

The air in those cross-block drifts is used to temper the temperature of the air coming out of the emplacement drifts because it gets pretty warm in there.

[Slide.]

MR. SNELL: I'll talk a little bit about the ECRB and what the relationship is with the layout that I just showed you for the repository.

[Slide.]

MR. SNELL: This was done in color. So it's not quite as easy to read on the viewgraph, but I think I can probably talk you through it and it will be clear in your handouts.

I think you are familiar with the footprint now. The cross-block drift as we envision it at the moment would be initiated from the north ramp, right about here.

I mentioned earlier that the thermal test facility is down in this area here where you see that little J-hook. So the references to the launch chamber for the cross-block drift refer to the launching operations in this region right here. That is where your cross-block drift would start. It is going to go up and over the top of the emplacement zone and run from northeast to southwest across the block, terminating down in this area.

There are others who are more erudite on the specifics, but in brief, there are two areas of principal interest on the cross-block drift that dictated the geometry that you are now seeing. One is variability in the properties in the selected host horizon from east to west is of major interest.

Most of the exploratory information we have is based on the ESF, which is on the eastern side of the block. We have drill hole information and other data on the west, some of it offset from the block, some to the north, some to the south.

There is clearly a desire to see what happens if you think about the cross section that I mentioned where you are sloping from west to east, you're sloping down. The repository host horizon, the eastern side of it is in the upper portion of that host horizon. The western portion of it is in the lower section of that same host horizon. The variability from east to west is important, but there is also a strong interest in seeing what the variability is in this emplacement horizon from north to south.

Again we have information around the footprint from drill holes and other information, but this ECRB cross-block drift with this kind of an orientation really gets you to both things. It lets you look at what is happening as you move across the block east to west, and it also gives you some ideas on what trends you can see south to north or north to south, either way. That's why the diagonal concept was tentatively selected. That's where we are right now.

It is offset from the repository horizon that we expect to use and it's above it by about 15 meters. We have done evaluations on how much of an offset you need to avoid interference between the ECRB and the repository itself and the structural and thermal analyses so far suggested about two diameters gets you away from cross talk between the two. So 10 or 11 meters is the standoff that is regarded as a minimum. This is laid out right now with a minimum separation of 15 meters a the bottom and about no more than 20 meters at the top.

It slopes, or will slope, to drain from south to north. That's the way the whole repository is sloped to drain, from south to north.

[Slide.]

MR. SNELL: A couple of comments on the interfaces. I have covered some of this already.

A minimum of 15 meters. It will be 5 meters in diameter. There is some tunnel boring machinery available with a 5 meter capability. I mentioned the grading from south to north.

[Slide.]

MR. SNELL: That drift can be used as part of the performance confirmation program. You will hear more about that later in the program. It would then serve a dual purpose, not only give us information on the geology early, but later on information as part of the PC program.

It does provide access to other performance confirmation drifts which you will hear more about later. There is an intersection between this one and those other performance confirmation drifts.

[Slide.]

MR. SNELL: As I mentioned, based on the information we have right now, we don't expect any impact from the ECRB on the repository. We do have drainage and we do have the separation.

You will get more detail on it later. We have a group that does something called determination of importance evaluations, DIEs. When the planning for this ECRB was initiated one of the early activities was to look at using the DIE techniques to look at possible interactions or adverse impacts from having the ECRB drift close to the emplacement horizon. That work was begun in that planning stage and the early results are what dictated the 15 meter separation, and so forth.

There is some additional DIE work that is still ongoing. There is a piece of it that will be completed over the next one to two months. I think completion of all the DIE work is early in the next fiscal year.

That's all that I have in this presentation. If you would like to ask questions, please do.

DR. NELSON: I am sure there are many questions sitting out there. I want to start off with a couple of questions of my own.

The first thing I would like to know, as you go through this design and carry it on into the VA, is there a percentage of the emplacement drift lengths that you are considering to be unusable because of conditions encountered when you do this planning? If there a percentage or some aggregate length of the tunnel that you would think you would not be placing in, how did you arrive at that?

MR. SNELL: At this time we do not have an expectation of unusable drift. I think our expectation right now is, based on what we know, we will be able to use all of the emplacement area.

DR. NELSON: So you expect 100 percent of the drift to be usable for emplacement?

MR. SNELL: Yes.

DR. NELSON: How are you going to get the tunnel boring machines at the end of one drift going back in and making a new tunnel? Are you planning on having it turned around at the end of one of the drifts?

MR. SNELL: The machines can be backed up; they can be physically moved. You can back them out of an excavation or you can turn them.

DR. NELSON: If you are putting in lining, you can't usually back them up.

MR. SNELL: We have access from both sides of the drift. If you are lining behind the tunnel boring, you can take it all the way across.

DR. NELSON: And then what? You're going to march it all the around and come back in this way.

MR. SNELL: You might. If you have to, you can disassemble the machines underground and move them in pieces. Are you concerned about damage to a concrete liner that is already in place?

DR. NELSON: Because the cutter head is usually full perimeter distance, you'd have to knock down the cutter head if you are going to back it out or somehow go to a specially designed tunnel boring machine that is a little bit shorter than the ones that would normally be made so that they would be turnable in the east or the west main.

That's fine. I'm after information in terms of what has been thought of.

MR. SNELL: You have pretty much any option you want. As I say, they can be pulled out or turned or disassembled or partially disassembled if you choose.

DR. NELSON: Will this whole picture of the step by step be part of the scenario that would be put together for the VA in terms of how the whole thing would be put together operations-wise? Like what you would plan to do with the tunnel boring machines?

MR. SNELL: I think that's a reasonable thing to do, yes. We hadn't gotten into that much detail in the VA documentation necessarily, but I think that's probably a good thing to include so that it's clear what the sequence will be.

MR. BARRETT: Dick, I would like to make a comment on that.

Probably not. The reason I'm saying that is we have got a lot of work to do. The critical issue from our perspective is the postclosure ability to do this. When it comes to digging tunnels and emplacement, there are a million good technical construction questions, like how do you do the tunnel boring machine and do you take it around on a train or do you take it apart, or whatever.

I believe the technology exists to be able to come up with the right way to do that, whatever it is. But that is not essential to determining the doability of a deep geologic repository. All that is is time and money. I believe good engineers will come up with how to turn tunnel boring machines around and all that sort of thing, but that is not central between now and the VA product.

I want the engineering people focused on the essential, most important first items which basically is, can you do it, and how good and how bad does it perform in the postclosure sense? Is there any reason from a surface or any preclosure issues that technology can't reasonably deal with?

So there should not be very much in this viability assessment that will address those very good questions. They are excellent questions. I'd love to play engineer on them, but we don't have a lot of time; we don't have excess resources to do a lot of that sort of thing.

DR. NELSON: That's fine. I'm trying to understand the scope.

MR. BARRETT: I'm constantly on his case: do not do a lot of preclosure stuff; focus on job one, postclosure and doability.

DR. NELSON: Let me ask if there are a couple of other things that may well, in your mind, fall into the same bin, which might be consideration of orientations of openings or diameter of the tunnels. They would have a cost impact. Will this be discussed in the context of VA?

MR. SNELL: It will be discussed. The current basis will be. The tunnel diameters are affected by several things, but the 5.5 meter diameter on the emplacement drifts, for example, is a diameter that is consistent with the large size waste package we have, the ability to move one package over another, and it's also consistent with reasonable construction machinery. I don't expect that to change between now and VA.

Based on what we know at the moment, 5.5 meter emplacement drift is a reasonable emplacement drift. I won't say we close the door on any other information we get, but we don't know of anything right now that would cause us to change that.

There was a second part to your question. I'm sorry.

DR. NELSON: Orientation of openings.

MR. SNELL: Right now the orientation of the emplacement drifts, those openings, is roughly a west-northwest orientation, and it's based on what we have seen in the tendency in the rock fracturing patterns based on exploratory information that we now have. The geotech folks tell you would like to cross faulted areas or major discontinuities head on; you don't want to get into a situation where you are parallel or quartering into them, if you will. They picked the orientation we now have as advantageous.

There is some indication that the orientation of the natural faulting does vary around the block. I think some of the conversations I've had is that it might be somewhat fan shaped, that is, more northerly trending at the north part of the site and tending to be a little more westerly or southerly trending as you move to the south.

We haven't seen that yet. If and when we do the ECRB at the cross-block drift, perhaps that will tell us a little bit more about those trends. It is possible, I would think, that we might modify the orientation slightly on the drifts. I don't think we have seen anything so far that says we've got something gross in the way of a change in orientation, but I'd hold an answer on that until we take a look at some more data.

DR. NELSON: Dan Bullen.

DR. BULLEN: You just alluded to something that sort of peaks my interest. Why are you preserving the opportunity to pick a waste package over another waste package for retrievability? Why do you want to do that?

MR. SNELL: It has some retrievability merit. That's not the only reason for it, though. Retrievability is one thing. We are still looking at various emplacement strategies because of the different kinds of waste that we have to deal with.

It is possible that if we go to mixtures of high thermal output and low thermal output waste package, we could get into a situation where we would want to insert a low thermal output package between two high thermal output packages in order to balance the thermal loading. It's an operational consideration.

From a retrievability standpoint, it might be a desire to retrieve a package of certain characteristics. Most of the waste might be performing just the way we expect. If you found something weird about some one package, some particular thing that was troublesome, you might want to go in and pull that one type of package. It's a fairly straightforward thing to do based on the designs right now. That's where we are at the moment.

DR. BULLEN: I guess the reason I have concern is the remote handling operations for something moving into a radiation field. Granted you never expect anything unexpected to happen, but when it does break it's a real bear to get it out. It's also very difficult to send people into that type of field unless, of course, you change to self-shielded packages and ventilation. Which actually leads me to the next question. I'll ask it real quickly and then defer.

MR. SNELL: One quick comment on the remoting.

Any remoting equipment that we put in down there we will have a very definite way of removing that equipment if it malfunctions. We are not going to send people down there on some kind of an ad hoc basis or temporary basis that I envision right now.

DR. BULLEN: I understand that. There is no way you would send anybody to that RMA.

MR. SNELL: Right.

DR. BULLEN: Things break.

MR. SNELL: Yes.

DR. BULLEN: Are you going to have the ability to pick up a waste package if you drop it off a pier?

MR. SNELL: If we drop it off a pier?

DR. BULLEN: If you break the pier and the waste package is canted in the side of the tunnel, how are you going to get it out? First off, you might not want to, but how are you going to get it out?

MR. SNELL: It's an accident scenario that will be evaluated. The equipment that we are looking at right now is a straddle type carrier. I honestly don't know to what extent our folks have looked at that specific scenario. It is, I would think, a realistic kind of an operational accident, and we'll have to address it.

DR. BULLEN: At the risk of not monopolizing you, I have one more quick question with respect to ventilation.

The ventilation you showed us, if we decide to actively ventilate throughout the entire lifetime, is the system adequate to do that, or do you have to make some significant modifications to it?

MR. SNELL: I'm giving you an answer off the top of my head, but I think the ventilation flow schemes that we use probably would not change dramatically. The ventilation quantities that we would use may change. When you asked the question, I assume you are thinking about the possibility of high ventilation flow rates in all the emplacement drifts for an extended period.

DR. BULLEN: Active ventilation while it's open, exactly.

MR. SNELL: In that case you need lots and lots more air. I mentioned that these are 600,000 cfm systems. Those system capacities would go way up. We are talking about more fans, larger airflows. When you look at the perimeter drifts and the air supply paths, maybe you need larger ducts, if you will, on the supply side where you are handling larger volumes. Possibly.

DR. BULLEN: And more shafts on the exhaust side, too, or will one shaft be enough?

MR. SNELL: More. In some of the extreme scenarios we looked at there are as many as a half a dozen shafts for air supply and exhaust because of the quantities.

DR. NELSON: Dick Parizek.

DR. PARIZEK: On the ventilator shafts, we don't see any filters implied either in the intake or the outlet. Will there be filters? I assume there probably would be on the exhaust part of it.

MR. SNELL: Yes. We didn't show them, but on the emplacement side we expect we are going to have a bank of HEPA filters for full flow capability and pre-filter systems. HEPA filters tend to load up with dust. This will be a fairly clean emplacement area, but my thinking right now would be that you would probably have either pre-filters ahead of the HEPAs so you could change those out and keep the HEPAs clean, or you might have a diversion system with monitoring and change the flow path from a normal filtration system to a HEPA flow if you had an accident.

DR. PARIZEK: On the east-west drift, if that's going to be used for confirmatory testing and you may have that open for ten or 15 years or more for observation, is that going to be a hostile environment from the point of view of temperature buildup? I don't have a sense of how warm that could be. That will cross a number of emplacement drifts that are already backfilled.

MR. SNELL: Once you get into the emplacement mode, I think from a personnel standpoint -- I'm giving you a guess right now; we'd need to look at some curves -- I'd say, yes, high temperature. Hostile from a radiation standpoint, I doubt it, because that much rock between the drifts probably gives you pretty good radiation shielding. But I think thermally, yes.

DR. NELSON: Debra.

DR. KNOPMAN: I have a couple questions. The first has to do with the sequencing idea, that you are going to start emplacing waste north and move to the south. To what extent will VA address the questions of differential heating that creates as you are moving down and the mobilization of moisture south of where you have got waste emplaced? That is, will you be creating wetter conditions as you are boring these new drifts?

MR. SNELL: It's an interesting comment. I would say the VA is going to have to address is fairly thoroughly. Right now the focus is especially on humidity conditions in the emplacement areas because we are looking at primary performance, and humidity is a very important performance indicator for the emplacement areas.

Influence on the development side, which I think is part of what you are asking about, is something we have not looked at in a lot of detail yet. I think to a degree yes, but the VA is going to have to address it because it's a reasonable question to ask. We have to deal with that as an operating environment on the emplacement side.

DR. KNOPMAN: If it's okay to do the east-west crossing above the repository horizon, would it also be okay to have the main exhaust drift above rather than below? Can you explain why the exhaust drift is below?

MR. SNELL: It was considered as an option that we put the exhaust drift either above or below the horizon. One of the reasons that we put it below was that the expectation was that we were going to have more than one performance confirmation drift. We expected the PC drifts to be above, or at least desired to have them above the working horizons rather than have an interference problem with them. That was part of the reason for selecting a ventilation drift below the working horizon.

DR. KNOPMAN: To what extent do you lose efficiency in your ventilating system by having your exhaust go up, the heat source?

MR. SNELL: There will be a full explanation of the ventilation system and why we have selected the system that we have. That will be in the VA. I think it needs to be there.

DR. KNOPMAN: You said the drain slope will go from south to north?

MR. SNELL: Yes.

DR. KNOPMAN: Why is that?

MR. SNELL: That's the trending that we see in the natural setting. If we do get water in the emplacement system, we would like to drain it that way. We need some drainage. I think the natural setting gives us a west to east and a south to north. We are in the footprint. When you get outside the repository footprint, the drainage patterns do change. I think you've seen some maps that show you that you get a southeasterly move on drainage and then gradually it moves over to a southwesterly move, but within the footprint it tends to be easterly and somewhat north.

DR. NELSON: Alberto.

DR. SAGUES: This is an elaboration on what Dr. Parizek indicated. Has anyone checked on the possibility of organic matters or biological matters brought in through the air circulation system? I understand it's about ten year or 15 years that this will be blowing at the 600,000 cfm.

MR. SNELL: You're talking about organics?

DR. SAGUES: Right.

MR. SNELL: With regard to performance of the ventilation system itself or just the presence of organics in the repository?

DR. SAGUES: The presence of organics in the repository.

MR. SNELL: That's an interesting question. I really don't. Organics is a major concern for the design part of the determination of importance work, the DIE work that I referred to earlier. One of the concerns there is organics and avoiding organics.

To what extent they have looked at organics that would be ingested, if you will, and carried underneath, I don't know. Steve mentioned that Peter Hastings, who leads our DIE work, is here, and later on when we get back into the ECRB it might be a good question.

CHAIRMAN COHON: Your slide number 4 was entitled Controlling Design Assumptions/Decision Process. I couldn't glean from that anything about the decision process. Could you say something about the decision process?

[Slide.]

MR. SNELL: I'll come back to this slide. As it turns out, the decision process for the footprint of the repository for this location is fairly straightforward. The ground rules that we have been given tend to give us a pretty good definition on the footprint. The decision process, I would say from a design standpoint, was as follows.

[Slide.]

MR. SNELL: These are indeed factors that influence the design. The geologic setting and the footprint that we have comes from many of the siting considerations.

Maybe I should talk a little bit more about these.

Good question.

Areal thermal loading is still under evaluation. Initially we looked at a range of thermal loads, and you will hear more about this later.

Anything from zero up to 100 metric tons of material was where we started. We have ruled out pretty much anything over 85 MTU per acre because of temperature limitations on the rock and temperature limitations if we want to preserve the zeolites underneath the repository host horizon. But 85 looks to be a practical number. You could go a little bit beyond that, but not much. Anything below 85 is feasible, it would seem.

We are doing comparisons now on which of the thermal loading seems to be most attractive. Zero would be perfect. That's no insult to the environment at all; 85 seems to be right near the desired upper boundary; the range of particular interest is 25 to 85, and we are still looking at it.

The reason we are still looking is that the areal thermal loading is very sensitive to several factors: how much water do you have? How much heat is released? How rapidly and to what degree do you drive off the moisture that is already present in the rock? How soon does it return? Those are all considerations in that selection. That's still under evaluation.

CHAIRMAN COHON: That's useful to hear.

Let me focus this, because I don't want to make you rehearse every one of these items.

Other than geologic setting, every other item on that list is basically not really set. There are ranges, and you just discussed the thermal loading. This is true for everything else. The physical package is subject to design decisions, et cetera, et cetera, et cetera. What I am interested in is the process you are following and will be following to integrate among all of these different considerations.

I do mean process. I don't mean the substance of it. How do you do it day to day?

MR. SNELL: The performance assessment work is the integrating tool for all that we are doing, because the performance assessment models are going to portray the performance of the repository. If we are going to present a case for why it works, how well it works, how sensitive it is to different things, it's the performance assessment results that have to convey that message.

The performance assessment work incorporates the various design features that we produce and it incorporates the scientific data which has been collected in the site characterization program.

The process that we are using is that PA is the focal point for our work. Our design people work actively with the performance assessment people in developing and exercising the model that describes the performance for the mountain. That's the only way that PA can correctly portray the design.

We work with them on such things as what's the corrosion behavior of waste package materials; what kind of waste degradation behavior do we get from the spent fuel forms that we are dealing with; how can you move waste forms out of the waste package through pinhole leaks or breaches or whatever; how can you get it out and into the near-field environment; how does it behave going through the invert. We help them in constructing and exercising those models.

The scientific people do the same on their side: how much water is there out there in the natural environment; how does it move; is it forced off by heat, and so forth. They help PA in constructing models in the same way.

So the process is PA is the backbone for the evaluation effort and the process is that PA, which is an evolving or an iterative function, is getting better and better. That's how we are converging on our design.

We have agreed with PA that at the end of fiscal year 1997, the end of September, we told the PA folks we will give them a set of design parameters that represent our design as we understand it now.

We are currently undergoing a review of essentially every aspect of our design that has a bearing on waste isolation performance. That's underway now. We said by November 15, approximately, we are going to get back with PA -- we work with them every day, but formally. That's all documented, by the way -- by the 15th we will get back with them and say, is there anything after review of every one of these aspects that drive performance, is there anything there that we think we need to change or modify. We'll hand that off to PA, and then they can begin their formal evaluation of the TSPA-VA item.

Science is in the process of doing the same kind of thing. PA has agreed that by the end of February or early March they will be able to accept some modifications of inputs that we have given them in November. In other words, they can tweak the models, if you will; they can take reasonable modifications.

If we come back to them with something that says, oh gosh, we just changed the waste package drastically, or the drifts got three times as big, or we changed the repository model, or something, that they couldn't very well deal with. But we are confident enough right now in what we have that the information we give them at this time is fundamentally correct, and we expect, like I say, within a couple of weeks now, three weeks, to give them a near-term update. They will use that as the basis for what they carry forward for PA models. In March we will give them any adjustments, corrections that we think we might want, and then they will go ahead and produce the VA product.

CHAIRMAN COHON: Thanks.

MR. BARRETT: Under the system we have in place, the design is controlled. Other than the first one, they are controlled in the design package that will be supporting the VA. They will have what the design is, what its basis is, and the bases for why we chose those. As things change we have the control board. They go to various boards. An engineer within TRW will decided minor things, and it will go on up the line. When they want to add billion dollar concrete liners, it comes to my office.

There is a whole hierarchy of people who have authority. People look at it and look at the cost implications, the performance implications, the constructibility, and all the various disciplines with appropriate qualified people look at it, sign off on it, document it in the QA space so successors can go and look and see why did you do what did kind of thing. There is a process and it is all written and documented.

CHAIRMAN COHON: That's good. To me the two key aspects among many are, one, the connection to TSPA, which you have explained well, and the other is making sure all of these issues come together in one place, and they seem to, so that you are seeing the tradeoffs and you are able to analyze the tradeoffs between the different components.

MR. BARRETT: He controls the design as the engineering lead person at TRW. He signs them off.

DR. NELSON: Let me ask one question, interjecting while you have that slide up. What do you interpret the retrievability requirements to be?

MR. SNELL: In brief, there are a few retrievability issues that are mentioned in the law, in the Nuclear Waste Policy Act, and there are some that are in 10 CFR 60, and there are some additional retrievability issues that are embodied in the program plan. We have collected all those into a set of requirements that are internally assembled, if you will. We have extracted what we have seen that relates to retrievability out of all those things.

There is a CRD document, which is a programmatic level requirements document, and we have repository requirements document and a control design assumptions document, all part of what Lake was talking about in terms of controlling design.

So whatever we have collected out of those sources we have incorporated into either the control design assumptions, which is under M&O control, or under the RD, the requirements documents, which is the DOE control. We put them in there and then we proceeded to design to those. We tried not to overly constrain ourselves. Requirements are literally that. If the law says you must have a provision for this or that on retrievability, we put it in. If 10 CFR 60 says you must be able to do this from a retrievability standpoint, we put it in.

Anything else that represents an extension of those stated requirements we would put in what we call the control design assumptions document. That's an internal control that we choose to impose, but it is changeable; it's under program control.

The true requirements on retrievability are quite limited, actually. There are two, three, four or five broad statements about you must be able to retrieve waste, what reasons you want to retrieve, and there are only two, I think, that are formally stated, and that's resource recovery and performance problems.

Those are very limited. Like I say, we have collected them, put them under our requirements documents where they are literally requirements that are mandated by law or by regulation.

DR. NELSON: Debra.

DR. KNOPMAN: Following up on Jerry's question about process of integration, to what extent will VA actually incorporate tradeoff curves? In this idea of transparency so that readers can understand why decisions at least to date have been made the way they have, will you actually have some curves that will show cost versus some continuum of, let's say, engineered barriers or some of the other variables, knobs you have two turn in various waste package design.

MR. SNELL: Curves and tables. For us to design the facility properly, as was mentioned earlier -- Steve had it on one of his charts -- it's performance driven design. If you can't make the repository do the waste isolation job that it's supposed to do and demonstrate it with PA, then nothing else matters. It has to be successful in that regard.

What I expect of the VA is, first of all, a set of performance curves that will be in PA and we'll probably have them in our design documentation as well that portray the design as we present it for VA. Then are going to be a several options that we will carry forward in reasonable detail. I would expect that we will have probably performance curves that depict how those options would influence the performance of the repository.

In tabular form, I would expect we will have cost data and other technical data on those options so that one can understand what they are, what those features are, what the performance implications are for them, and how much are they worth. As Lake said, the level of detail may not be precisely the same as what is in the VA design, but it is going to be adequate to understand them, understand their performance, and have a pretty good basis for recognizing what the cost implications are if you choose to exercise the option.

MR. BARRETT: The four sub-products within the VA will basically describe the reference design and be a summary of the design packages, which will be hundreds of TRW deliverables and will some degree talk about some options. Like the backfill we mentioned; the major options.

Beneath the four VA products are nominally a million pages of TRW and laboratory deliverables: scientific analysis of an experiment; or some of Larry Hayes' reports from USGS; engineering studies. In many of those engineering studies you will find parametrics, what if this, what if that, and a conclusion.

The actual design package section in the VA may not have it. The underlying will have it. We are going to great pains to try to have all of these reports, of which there will be hundreds, available to everybody as part of the technical and scientific feeds into the four VA products. The four VA products themselves may be less than 1,000 pages. I hope they are.

For example, there is a study that we did about small waste packages. I know the Board had asked for copies of that. That included the pros of cons of small versus large and what the history was. That's in the suite of documents that were feeds. You will find some things we did, some things we didn't do, some options we kept open, and some options we will study later that we haven't even thought of yet, or somebody hasn't thought of them yet.

So you will find that in the companion documents to the VA, which is sort of the basement of all the scientific reports that feed the four VA products, there should be a lot of those kinds of things. I doubt there will be a lot of those parametric tradeoff things in the four VA documents themselves, but they will all be together. A lot of this we are still working out to try to make it understandable but not be a million pages, a truck full of books.

CHAIRMAN COHON: I can't help pointing out we are going from about one million pages to 1,000 to the one page memo to Congress.

[Laughter.]

CHAIRMAN COHON: I have some short questions which I think have very short answers. It just shows that there are things I just don't know that I need to.

What are the assumptions on worker exposure in that phase development and emplacement procedure?

MR. SNELL: On the emplacement side and in active radiation areas there are a set of formal guidelines that are imposed both by Code of Federal Regulations and by DOE orders. We will satisfy the normal operational requirements in terms of radiation exposure for 40 hours a week for normal workers.

CHAIRMAN COHON: Why do you need standby drifts?

MR. SNELL: Standby drifts are there for unexpected or unencountered conditions. They may help us on that mix and match of waste that I was talking about. We might find operationally that we put a package in and they look at the areal loading that they are trying to match and decide that another package maybe should go in. They'll back one out and put another one in.

CHAIRMAN COHON: Rather than having to take it all the out, you can just store it in a standby?

MR. SNELL: Yes. You can sort of put it on hold and then put it back in.

CHAIRMAN COHON: A final one. The answer should be yes or no, I think. We'll see.

MR. SNELL: Thank you for the guidance.

CHAIRMAN COHON: Is the following characterization a fair characterization, that the ECRB geometry was chosen because of the interest in understanding north-south variation as well as east-west variation? I'm just repeating what you said.

MR. SNELL: My answer is yes.

CHAIRMAN COHON: I'm not done with the question.

MR. SNELL: Sorry.

[Laughter.]

CHAIRMAN COHON: If the interests are only east-west, one could have dug an east-west drift that coincided exactly with the future emplacement drift, should there be one.

MR. SNELL: That's true.

CHAIRMAN COHON: But it's because of the interest in the north-south variation as well that we now have the ECRB displaced above the repository level.

MR. SNELL: Above and moving diagonally across.

CHAIRMAN COHON: It's because it's moving in this diagonal fashion that it must be above so as to minimize interference with the repository itself. If we were only interested in east-west variation, we could have just gone right through the repository block; we could have dug an emplacement drift.

MR. SNELL: That's true. I believe that's a correct statement, that it's an interest in north-south as well as east-west. There are other who have more background, but that's my understanding.

CHAIRMAN COHON: Thank you.

MR. BARRETT: I would add one thing. If they would have come to me and said, I want to dig an east-west drift for exploration and it's down looking like what an emplacement drift would have been at the bottom, I would have had a say about that.

I'm not sure what I would have said, but I'll tell you what weighed heavily on my mind -- Lyons, Kansas. We think we know a lot about engineering; we think we know as lot about design; we don't know what it's finally going to be. We can approximate it and say technology and engineering can do it, but there is a lot we don't know yet as far as detailed designs. Before we go into the block I want to be darn sure we are right before we go ahead. I don't think we are there yet. So I would hesitate going into that block until I knew a lot more about it, until there was more uncertainty resolved.

DR. NELSON: Do any of the consultants have any questions?

MR. KUHN: My question goes along the same line. The footprint of your repository is very schematic and very homogeneous. How are you sure that the detailed geology is as homogeneous as was supposed? You haven't talked about in pre-investigation using any boreholes or geophysical tools. Is this foreseen or not?

MR. SNELL: There were a substantial number of pre-investigations. There is borehole data that has been collected over several years in the site characterization programs.

I missed the point of your question. Would you restate?

MR. KUHN: That's not the point of my question. The question is about a detailed pre-investigation of the block which is foreseen to be used for the repository construction for the drifts.

MR. SNELL: I'm probably not the right guy to answer the question.

Larry.

MR. HAYES: Larry Hayes, M&O.

In addition to the east-west drift that will give us information not only in an east-west but also a north-south, we also will get information about the entire vertical sequence of rock that we expect to encounter in the emplacement areas. That we don't have now. With the exploratory studies facility we sort of went along one part of the potential repository block. The east-west drift will give us information in the entire vertical.

Additionally, we are drilling three boreholes: SD-13, which will give us information in the entire vertical up to the north part of the block; SD-6, which is on the central western side.

[Slide.]

MR. BARRETT: Larry, we put a viewgraph up for you.

MR. HAYES: Good. You can see SD-6 on the central western side. That will give us vertical information as part of the ECRB. Then SD-11, which will give us information on the southern western part of the block where we lack information. Those three boreholes are very important to the question you asked, getting vertical variability as well as horizontal variability.

Before we drill these boreholes -- we are in the process of doing it now -- we have our 3D geologic framework model that was constructed on all the geologic information we have, and we will predict what we expect to encounter in the boreholes. That will help us not only validate our model but also improve our model.

So I think by the time Dick is ready to construct emplacement drifts we should have a pretty good handle on what you are asking.

MR. BROCOUM: Let me make one comment. We would have liked to have done SD-11 and SD-13 this fiscal year. We already are drilling WT-24. We are ready to start SD-6. Then we could have moved on the other two. But our budget constraints had us defer those two holes.

The other comment I want to make about SD-11 and SD-13. When we had that three month team planning the enhanced characterization, the value of SD-11 and the value of SD-13 in that team's opinion equalled the valued of the east-west drift.

MR. SNELL: I would like to make one other comment in response to that question. Any time you do mining or underground work you are going to get surprises. Priscilla asked a question earlier that relates to this, about do you expect to use 100 percent of the available space. I remarked that we do have probably 10 to 20 percent of surplus available area in the footprint.

I would be really surprised if we didn't get surprised somewhere in the underground development. Nature does that to you. I fully expect that as they go through the exploration and development of the underground they are going to find places where we can't do what we expected to do, and we're going to have to perhaps abandon a drift or modify the details of the drift design locally or do something else in order to respond to that condition. I think that's going to happen.

I suppose I have oversimplified the response. I would just say that I think we have enough area available to us so that we can respond to those kinds of problems, and I do believe they are going to occur.

I would say that from the information we have scientifically so far we haven't seen huge variability in the features. We have gotten fairly consistent kinds of data. You don't see abrupt sort of changes in the footprint that we are working with right now. The combination of what seems to be reasonable gradations in character of the stratigraphy that we are in and having the extra available space gives reasonable confidence that we can go ahead with a development that is going to look like this.

DR. NELSON: Thank you.

To finish out the session, we are going to let George Danko ask a question. Then we will finish off with Richard Parizek, and that will close the session.

MR. DANKO: I would like to ask you a question about the number of shafts which may be needed to increase the ventilation air volume and keep the repository maybe accessible for the full period of the closure. You mentioned about a half a dozen shafts which may be needed. I would like to ask you if it is really a problem or whether DOE considers that having more shafts and being able to sequence the repository would be a benefit instead of a liability.

MR. SNELL: Several comments. First of all, I said six. I think the number I've heard is from four to six, depending on how you design the system. We are currently doing evaluations of the relative benefits of continued ventilation. I think we've had questions along those lines from several people, and we are doing some of that work now. I expect we will have some answers fairly quickly. We are looking at both ventilation for shorter terms and for longer durations. What we are looking for especially are things that would help us with waste isolation performance, a long-term benefit, if you will.

So the answer on what the value is of that, in our minds anyway, is still under investigation.

So far I do not know of any reason why adding more shafts would necessarily be a problem. I don't think that there is some physical constraint or geological condition or something like that that would prove a problem. They do cost money.

MR. BROCOUM: Dick, there is a preference in 60 to minimize the number of openings.

MR. DANKO: But it is not necessarily a dogma which is carve din stone?

MR. SNELL: They would ask you to justify it.

MR. BARRETT: As a basic principle, you would like not to put more holes into where you are putting the waste than you need to. If it's better to have good ventilation, it's a tradeoff of competing goods, and we'll have to balance that. There is a consideration about putting extra holes and pathways into where you are going to put in material. Can you do it? Yes, you could, and you must properly trade it off, and Dick is doing those tradeoffs.

DR. NELSON: Carl Peterson.

MR. PETERSON: This is a question kind of on design philosophy. Priscilla ask a question about what's the meaning of retrievability, and the answer was kind of it's a legal requirement. That's the easy part. If something has to be retrieved, the likely reason is something is going wrong, and it probably isn't going wrong in isolation; everything around it is deteriorating. It seems to me this could influence the entire design, the simplicity of the design and the choice of materials and all that. I hope that is in the process not just with that issue but with the whole issue of the long-term state of the repository.

MR. SNELL: It is. You'll hear more about the performance confirmation program. I think that is one area where probably some choices have yet to be made in terms of how long do you want to run a performance confirmation program and what might you do with the results that you get from such a program.

Retrievability -- there are some must-dos that the regs and the law prescribe. We have to satisfy that. The extent to which you want to extend those capabilities is something I think that still has to be discussed. We haven't slammed the door on those kind of things.

MR. PETERSON: I think even the must-dos require some careful thought in the basic design. I'm sure you agree.

MR. SNELL: They do indeed.

DR. NELSON: Last question to close it out.

DR. PARIZEK: There was a question about the three boreholes. I'm not familiar with what is planned in each of those. They could be very useful, as was implied by the response, or not so useful. The stratigraphy of the rock, is it water contents and isotopes and pneumatic tests, and so on?

MR. SNELL: I don't have the specific details on those boreholes. Larry may have those in his head.

MR. HAYES: The answer is yes to all your questions. The boreholes will provide information on geology, mineralogy, hydrology, isotopes, the whole thing.

DR. PARIZEK: Does the Board have a study planned for that drilling program?

MR. HAYES: We certainly have detailed plans on the boring program that we could get to you if you would like.

DR. NELSON: I thank you very much, Dick.

MR. SNELL: My pleasure.

DR. NELSON: And Steve and Lake for your contributions this morning.

We will adjourn the session now to reconvene at 1:15. We have a full session this afternoon. Thank you.

[Whereupon, at 12:10 p.m., the meeting was recessed, to reconvene at 1:15 p.m., this same day.]

AFTERNOON SESSION

[1:25 p.m.]

DR. NELSON: Welcome back.

Again, my name is Priscilla Nelson and I am coordinating the presentations for the first part of this afternoon. Following a break at about 20 after 3 or 25 after 3, I will turn the control over to John Arendt, who will run the rest of the afternoon sessions.

It is my pleasure to introduce to you three presentations that will present to the Board information on repository thermal management, engineered barrier systems, and the alternative repository concepts.

Our first speaker this afternoon is Jim Blink with the M&O. He's out of Lawrence Livermore National Laboratory, and he will be speaking on the status of the thinking in repository thermal management.

MR. BLINK: I guess I have ten seconds left in the talk. I have 15 minutes to speak and we are 14:50 behind.

DR. NELSON: I know you are eloquent, but let's not push it.

[Slide.]

MR. BLINK: What I am going to go through today are:

What are our thermal goals, how have we in this design process put together some limits for ourselves, how are we doing on meeting those limits

Extending that picture from individual component limits to the overall performance of the entire mine geologic disposal system to the bottom line.

Some words about how ventilation might affect thermal behavior.

Finally, something in response to what Jack Bailey is going to talk to about later. Jack is going to show you four design options that we are carrying for the VA.

One is cladding credit. The other three all influence the performance of the cladding, but that's not the reason they are in there. They are backfill, drip shields and a ceramic coating on the waste package.

In each case those do something for a component in the EBS but they also increase the temperature of the cladding, which is a negative effect. So I am going to show you some means to counteract that negative effect on the cladding, some means other than those three options, and then finally a quick summary.

[Slide.]

MR. BLINK: Here are our assumptions, our requirements, our goals, or what have you.

The first one is we are going to have a high range of thermal loading, 80 to 100 MTU per acre. That's our reference design assumption. The reason for that is that level of thermal loading will accommodate the 70,000 metric tons that are in the law, the Nuclear Waste Policy Act, in the area that we are characterizing. It's predicted to have an acceptable performance, and finally, the higher the thermal load in general the lower the cost and the smaller the footprint.

Since we really don't know if, for example, the acceptable performance is true or not, there is an uncertainty on that, for risk mitigation we are going to carry some alternative thermal loads, at least from the viewpoint of doing conceptual work on them.

We are actively considering thermal loads down in the lower end, 25 to 36 MTU per acre, in many of our various studies. I guess I would advocate looking at a higher level as well, although we are doing that to a much lower degree. I will get back to that a little bit later.

This is documented in our controlled design assumptions document, which is where we collect the things that are in the higher level requirements documents plus add our assumptions, and it's key assumption 19. In all the rest of these charts I have abbreviated it CDA.

The second thermal goal that we have set for ourselves is what we call point loading. That is, we decide to space our waste packages based on the metric tons of uranium equivalent that is in each one.

Point loading is a misnomer. Point loading would really mean that each waste package is an individual isolated heat source and the heat effects don't overlap. We are not that far apart. So point loading is the other extreme from line loading where the waste packages are right up end to end. We are actually somewhere in the middle there, but we do tend to call that point loading.

For this one the defense high level waste packages are assumed to have no metric tons of uranium equivalent in them and we just insert them in the spaces between the larger commercial packages.

If we do this within the areal mass loading constraint above and the temperature limit constraints I will show you in a minute, if we do the point loading, then we maximize the drift spacing and we minimize the waste package spacing, and that reduces costs.

[Slide.]

MR. BLINK: What are those temperature limits? Here is one, the zeolites. Zeolites are minerals that are below the repository horizon and at the horizon as well that sorb some or our radionuclides. In order to get a reasonable amount of sorption from those zeolites, we have set a limit of 90 degrees C and we imposed that limit on all areas that are more than 170 meters below the repository horizon.

That sets the areal mass loading. If you do a conduction-only calculation, you get a number of 85 MTU per acre, and that is our reference case right now. That's embodied in the CDA design concepts subsurface assumption number 25.

The second temperature limit is the drift wall temperature. We have set that at 200 decrees C, which is a nice round number. For the reference drift diameter, that sets the drift spacing to 28 meters and consequently sets the waste package spacing.

The rationale for this is we want to limit the thermal stress in the near field. That's really an input to the subsurface designers. We could have a higher thermal stress and they would just have to use more engineering means to accommodate it.

The reason that we picked that 200 is up around the 225 to 230 range cristobalite, which is up to 50 percent of the rock, has a phase change that causes it to swell. So we are trying to stay well below that phase change.

There is another mineral, tritomite, that has a phase change at lower temperatures, but it's not nearly as extensive a component.

[Slide.]

MR. BLINK: The third major temperature limit is the cladding. We have set a limit on that of 350 degrees C.

The reason for that is cladding can give us one to two orders of magnitude improvement in our bottom line performance, that is, the peak dose rate at the accessible environment. So it's important to look at that. Right now we don't take credit for it in our performance assessments other than in our sensitivity cases.

The reason you get the one to two orders of magnitude is intact Zircalloy cladding is 98 percent or more of the received waste. The inventory is projected to have a tenth of a percent failed Zirc cladding when we get it, and that is based on what failed in the early days plus the current kind of failure rates, which are very, very low, and a little bit over one percent of the cladding is stainless steel cladding, and we expect that would probably fail in the repository environment, although there may be some performance to be had from that. If you just take the intact cladding, you get 98 percent, which is almost two orders of magnitude.

The intact Zircalloy cladding is very resistant to corrosion. So it would limit the radionuclide mobilization.

To get that mobilization you have to have to independent failures.

The first one is you have to have enough internal pressure in that cladding due to the temperature that the fission gases and the cover gas in the fuel pin make enough of a pressure that the pin creeps and eventually perforates. When it perforates you end up with about a 10 micron pinhole in it, which relieves the internal pressure, and after that you have no further problems.

If the second failure happens, that is the waste package breaches so you lose the inner gas that is in the waste package and replace it with whatever gas is in the drift, if there is free oxygen in that gas, that free oxygen can go through that pinhole and start to oxidize the UO2 to a higher oxidation state. The U3O8 swells significantly from UO2 and causes cladding gap or pinhole to spread, and it literally unzips and gets a longitudinal split in it up its length.

Furthermore, that expansion of the UO2 increases its surface area by a lot so that it would dissolve faster if water came. The only time that that can happen is within the first 150 years, because after that the temperature is below 200 degrees C and the oxidation process is much slower below 200 degrees C.

So we have to have these two independent failures in order to lose the cladding. We are pursuing now as to whether that can happen.

[Slide.]

MR. BLINK: There are four other temperature limits that have. I won't go through them in detail. You can just look at them up here:

Temperature limits in the shafts and ramps.

In the main drifts.

In the Paint Brush tuff non-welded unit above the repository horizon. That one is so we don't have further fracturing up there creating more fast paths.

Finally, the surface temperature rise of 2 degrees C, which is an ecology type of limit.

[Slide.]

MR. BLINK: So how are we doing at these meeting these goals?

I have shown here the three limits that I discussed earlier: the cladding as a horizontal line; the drift wall, the 200 degrees C; and the zeolite, the 90 degree C.

Then the curved lines underneath show the performance of the reference design. Actually it's a calculation similar to the reference design. This is a thermal hydrology calculation and it was for a slightly earlier design that had a closer drift spacing, but it's good enough for this purpose.

The green is the margin that we have to each of those limits, and the margin is a reasonable margin.

For cladding I have shown you two. One is for the hottest package and the other is for the average package.

But those three limits really aren't the bottom line; the bottom line is the peak dose at the accessible environment. So how do you deal with that?

[Slide.]

MR. BLINK: Well, we can't tell you with numbers right now. Our models are not sophisticated enough to get at that, but that's what we are working at in TSPA-VA.

What I have done here is given you a notional plot. Please remember it's notional. There is no scale on the y axis. I don't even say whether it's log or linear.

I show you the areal mass loading on the x axis. Let's just start out over here. At zero areal mass loading, that is, you take the 70,000 tons and you spread it out in a huge repository underground, no well downstream will see enough of the source to get much dose. Basically the source is diluted. So you would have none.

As you start bringing the repository footprint smaller and smaller you get more and more source term and you get more and more heat. The heat accelerates the failure of the waste packages and accelerates the mobilization of the radionuclides, and so it keeps climbing.

Eventually the heat starts to do you some good. Eventually you have enough heat that you can drive the water away from the near-field rock, and since water is the thing that causes the waste packages to fail and mobilizes the waste, if we can get rid of it, that should give us some performance. So the performance starts getting better as we heat it up.

I've shown here the three limits that we have set for ourselves in those three components, and I claim that the performance probably gets better as you go beyond that, although we don't have enough calculations to really demonstrate it.

Eventually, however, you are going to get to the point where the heat and the free oxygen is going to cause some of those early waste package failures to breach the cladding; you are going to cause the zeolites down below to overheat and dehydrate and evolve to another mineral that is not sorptive; and you will even start to put a lot of cracks in the near-field rock.

Eventually the performance will turn around and start getting worse and it will get worse and worse as you add heat until finally it levels out at some intrinsic value that is limited by things like solubility of radionuclides, percolation flux, and dilution in the saturated zone, all things that are sort of far away from your EBS design.

We would like to in this project put numbers on this graph and do it right, and that is one of the goals of PA and of the organization that I'm in, part of engineering called design basis models.

[Slide.]

MR. BLINK: How do we get at that? We have to go step by step.

The first step is to look at the temperature on the waste package, because the temperature on the waste package is one of the key inputs to the waste package survivability, its life.

This is from the same calculation. I showed the hottest average and the coldest waste packages as a function of time what the temperatures are. I don't have any limit lines or green areas of margin because we have no limit except for the waste package yet.

[Slide.]

MR. BLINK: At boiling you have one atmosphere of water vapor pressure. If you go above boiling, the saturated water vapor pressure is above an atmosphere. But we can only have one atmosphere of pressure in the drift because the drift is connected to the fractures in the mountain and eventually to the outside world. So that means that we have less water vapor in that drift than could be there thermodynamically. It means the humidity drops.

What happens with the heat is we drop the relative humidity down below 50 percent for centuries. By the way, that implies that all of the gas that is in the drift is water vapor, that you have excluded the air by pushing it away with the water vapor.

Low humidity gives us low corrosion. So that's a good thing. Well, how can we put that together into a performance calculation?

[Slide.]

MR. BLINK: This chart is a little complicated. So I will take a minute or two to go through it.

What I have done is cross plotted the previous two graphs, the humidity on the side and the surface temperature across the bottom. First let's look at the green and the white and the red regions to define the corrosion windows of susceptibility.

For the outer barrier, the corrosion allowance material, it fails by humid air corrosion, and humidities as low as 50 percent could cause humid air corrosion if you have salts on the waste package.

How could you get salt on the waste package? If water seeps and drips into the drift and lands on the package and then boils off, it leaves behind any salt that was dissolved in it. If we have that situation, we could have humidities this low causing this corrosion. If you don't have that situation because you have something in between like a drip shield, then maybe the limit is in the 80 percent range.

I have shown a slanted line here up to room temperature, 25 degrees C, at 100 percent humidity. By the way, our ambient condition is about 26 degrees C and 98 percent humidity. I have shown that slanted line because lab tests have shown that we can have humid air corrosion down to room temperature, and it's slanted because we think the corrosion is faster at the higher temperature than the lower, but that slant is just notional.

I have got a slant on this side as well, because at the higher temperatures you can get boiling point enhancement by having stuff dissolved in your liquid solutes and by having pores in the surface.

For the corrosion resistant material I only have a temperature window of susceptibility. The red is the temperature limits in here that you could have crevice and pitting corrosion of that inner nickel base material.

So how do we use this?

First of all, we can't be out here in the white, because that would imply a pressure greater than one atmosphere in the drift. So we are in the green or the red regions only.

We start out up here at ambient, and by ten years the hottest waste packages reach that place. It's 200 degrees C, about 5 percent humidity. Then it starts tracking up this one atmosphere of water vapor pressure line. At 100 years it's here; at 1,000 years it's here; it turns over at 10,000 there at about 60 degrees; and finally at 100,000 years it's back to the normal original starting point.

What about the cold waste package, the defense high level waste? The H standards for Hanford, by the way. At ten years it's there; at 100 years, 1,000, 10,000, and 100,000. So it follows very much the same path. It just doesn't get as dry and warm at the beginning.

If you are in this red region, you are corroding, and you probably lost a few thousand years perhaps in that environment before you breach that 10 centimeter thick outer barrier, at which point you have to look and see what temperature you are at, and you look up into the inner barrier. If you are in the red there, then in a few hundred to a few thousand years that barrier breaches.

The goal of design here and the goal of PA is, can we find an engineered barrier system configuration that has a path that goes like this, that stays in the green? Then if you do have some sort of failure, maybe a juvenile failure, manufacturing defect, you pop up here into the green there.

If we can find a design situation like that, then we are in really good shape. But this is what our current design is right now and we can use this sort of thing in our PA models to estimate performance time. For all of the design options that Jack is going to show you we draw plots like this to see how we are doing.

[Slide.]

MR. BLINK: Currently, our ventilation is a 10th of a cubic meter per second in the drift once we have filled the drift with waste packages. That is a very low level, and it's there primarily so that we don't have backward flow. In case we had any sort of failure we wouldn't want any radionuclides to go backwards into the drifts that are occupied. We want it to go forward to the place where our sensors and filters are. So we are removing some water with that but we are not really limiting the temperature very much.

In the ESF we have done measurements and quantified how much water we are taking out in the ventilation system, and it works out to be about 200 millimeters per year based on the surface area of the drift, and of course that drops with time as we dry out that near-field rock.

The design group has done calculations as to what you would have to do to blast cool the drift to bring it down to a temperature that you could operate equipment in in case you had to retrieve or do some sort of a repair operation.

University of Nevada-Reno, as the Board well knows, has been doing calculations like this for sometime. I believe George Danko has given you a report. We currently have George under contract and he is doing some of that work for us as well, and I will show that in a minute. He's looking at natural convection in both open and closed repositories. By open, what I mean is you keep a shaft open so that you can get natural convection but you have the shaft sealed in such a way that you can't have people go up and down it, just air.

[Slide.]

MR. BLINK: Let me show you the results of design calculation. Right now we are at the 0.1 cubic meters per second.

What happens if you go up to a factor of ten more or a factor of 100 more? You can see you drop your temperatures from the 140 degree range down into the 40s and 50s, so you get about 100 degree C temperature reduction if you are willing to pay the price to build those extra half dozen exhaust tunnels and half dozen inlet tunnels or shafts.

This is an important number to me. How much of the 100 year integrated heat load that came out of those waste packages was removed by the ventilation system? Current design has taken out about 8 percent, but you can see we can get up to 50 percent at an order of magnitude increase and up to over 80 percent at two orders of magnitude increase. So there is something to be had there as a design option, and we are looking at it.

[Slide.]

MR. BLINK: This is one of the pictures out of Dr. Danko's reports. What happens if you move the central exhaust drift above instead of having it below? In this case he's got it 30 meters above so that we have enough temperature difference between the two elevations to give us enough buoyancy to cause the air to move.

The airflow is like this. It comes in from the perimeter drift to the center, up the upcomer, along the central main exhaust drift, outside sideways in the performance confirmation drift, and then back down some downcomers that we would have to add. So you just have a closed loop circulation there.

That does three things for you. Number one, it limits the peak temperature in the drift, because it tends to smooth the temperatures out along the drift by more effectively transferring heat from the highest temperature packages than from the lower temperature packages.

Secondly, it actually removes some average heat deposited in the performance confirmation drifts above.

Thirdly, that movement of heat and the relative humidities involved will cause some of the water to be vaporized from the near-field rock at the repository horizon and deposited up in those performance confirmation drifts.

If you do the design of those drifts in a way that the water drains out to the perimeter, it doesn't have a chance to come back on you, and even if you didn't do that, if you just let it percolate in, the drifts don't occupy 100 percent of that plane underneath, so a lot of it is going to pass through and miss you. So this is way to limit the water as well.

[Slide.]

MR. BLINK: Let's talk about the cladding for a minute. Let's say that we adopt one of those three options or some other options that give us performance but also increase cladding temperature. Is there anything we can do to counteract that?

We have aluminum shunts in the basket inside the waste package. We can just add more aluminum to those, which means that we reduce the temperature difference between the cladding and the outside waste package and gain something there.

Another thing we can do is something called thermal blending. Thermal blending is mixing and matching the assemblies above ground in the waste handling building so that instead of having waste packages that are 10 plus or minus 8 kilowatts, maybe they are 10 plus or minus 4 kilowatts. That would limit the peak temperatures. Remember that earlier chart with the green. It was only those very hot packages that got near the cladding limit.

The standby drifts that Dick Snell talked to you about are a place that you could temporarily park a hot package and ventilate it pretty strongly and take it out after it had cooled down some and move it into its final resting place in the emplacement drift. You just leave a hole for it as you are emplacing the rest of the packages.

You could increase the waste package spacing and reduce the drift spacing. It would become more of a point load type design so that the heat fields don't overlap.

You could go the other direction. You could line load. If you line load the packages so they are nearly touching other so that they radiate to each other, the cold package acts as a fin for the hot package. That way the hot package loses more of its heat proportionally because the radiation to the next metal package is more effective than radiation to the rock. That will smooth the temperatures between the packages but it will not lower the average temperature; it will not lower the peak temperature of the hottest waste package but it will smooth things more so that you don't move water from one package to the other as much.

Finally, the preclosure ventilation that we talked about.

[Slide.]

MR. BLINK: To summarize this, the reference design we expect to meet DOE's guidance as far as peak dose at the accessible environment, but there is some uncertainty in that expectation.

The design features that Jack is going to talk to you about do have the potential to significantly reduce those dose rates but they also tend to increase cladding temperatures.

Finally, we have identified some methods to compensate for that increase in cladding temperature.

DR. NELSON: Thank you very much, Jim.

Let me ask you one question. All of your analyses on temperature were for a 5-1/2 meter diameter opening?

MR. BLINK: Five and half meter as mined; five meters after we install the liner.

DR. NELSON: They all include liners in that analysis?

MR. BLINK: Yes, they do.

DR. NELSON: How important is the diameter assumption on the conclusions that you made here?

MR. BLINK: I guess I would ask Tom Doering or Dan McKenzie to answer that. I think they have both done parametric studies of that in the past. I don't think we have done it much recently and I don't think there was much effect. I think Tom is back there somewhere. He said he would be.

DR. NELSON: He's finding a slide.

MR. DOERING: Tom Doering with the M&O. The drift diameter does have an effect on the overall package and cladding temperature. We went all the way down to a 3 meter drift and found that it was not tolerable to the larger packages, the 18 kilowatt packages. About the smallest we can get down to is 4.3 or comfortably 4.5 meters before we can say that we can accommodate all the waste that is supposed to come our direction without having over temp.

DR. NELSON: Linked to that, have you investigated if you use something like ventilation how much more closely spaced the packages and/or drifts might be? Is that a parameter that has been considered?

MR. BLINK: That's one of the things we were looking at in a study that we have been doing recently. We don't have the results on it yet, but we are combining 50 years of aggressive ventilation with, say, adding backfill. We have been asked to look at can we employ some of these means to lower dose rate and still close at 50 years. So we are looking at that as a means, but we don't have numbers to show you yet.

DR. NELSON: Any other questions.

CHAIRMAN COHON: Are all of those temperature limits, the various ones that you identified, fungible so far as you are concerned? That is, can any one of those be changed if one can come up with a good reason for doing so?

MR. BLINK: Sure. You can trade them. For example, the 200 degree C. Clearly you could change that.

CHAIRMAN COHON: Good enough. None is hard constraint?

MR. BLINK: That's true.

CHAIRMAN COHON: On the red and green diagram -- you don't have to put it up -- are you or someone else doing experiments to firm up the shape of the location of that red?

MR. BLINK: Yes. We have a department called waste package materials, and one of its prime functions is to do the experiments and the analyses to lay that out for us.

CHAIRMAN COHON: Do you expect that that is going to remain very uncertain, or do you think we will be able to get a good handle on that from these experiments?

MR. BLINK: We will get a much better handle on it than we have now, but the corrosion process does have some statistical features in it. You're never going to get it down to a tee, but certainly you can get it to within an order of magnitude.

CHAIRMAN COHON: Thanks.

DR. NELSON: Debra.

DR. KNOPMAN: In terms of VA, how much more refined do you expect the red and green figure to be than what you showed us today?

MR. BLINK: I was reading a report on the plane about the upper range. It's already getting more refined. On the lower one there are humidity chamber experiments ongoing that are giving us results. So I think we will know that considerably better.

DR. KNOPMAN: You didn't say much about water vapor refluxing and anticipated flow paths and how you use the design features, particularly spacing between drifts to work to your advantage for that. Could you say something about how that is figuring into your design process?

MR. BLINK: At 85 MTU per acre for the point loading the boiling isotherms do not coalesce between the drifts, so that you end up with a sub-boiling region that you can shed water through between the drifts. If you went to a line loading case, you push the boiling isotherms out farther and coalesce them axially more, but still you leave some space.

So we think there will be a considerable amount of shedding from the water that we mobilize. We calculate we will mobilize some hundreds of millimeters per year of flux, and that will persist within a few diameters of the drift for decades to as much as a couple of centuries, depending on the way we lay out the packages. That's definitely a concern because that's a number that is at least an order of magnitude bigger than the ambient fluxes. So we are working that.

In addition, the fact of refluxing itself creates low porosity areas and high porosity areas. You get low porosity where the boiling is taking place and high porosity where the condensation is taking place, and we think that has the potential to make a mineral cap above the repository that acts somewhat as a flow diverter or an umbrella, but it also can deposit minerals in those pillars and underneath the drift.

We are actively looking at that. We have lab scale experiments and three dimensional reactive transport codes that we are using to model the experiments and then extend the model out to repository scenarios.

DR. NELSON: Alberto.

DR. SAGUES: The assumption that the steam from the evaporated water will effectively sparge the drifts seems to be common in a number of these modeling approaches. What is the likelihood in your opinion that maybe it will not work that way? For example, that water condensation at the edges of the drift areas will effectively reduce the partial pressure of water in the system and therefore you will end up with a significant amount of air left in the tunnels.

MR. BLINK: That's a really good point. I'm not so much thinking about the condensation of the water, because as long as we are well above 100 degrees C we are not going to see that. But I think about convection currents using the natural fractures in the mountain linked up with the drifts to get gas flow that brings fresh air back in. So even though thermodynamically it wants to be all water, if you bring air in, you have some mixing and so forth.

To fail a cladding you need three things. You need to have oxygen, you need to fail the waste package to get it in contact, and you need to have the creep rupture. We are really only thinking about two of them. We are not thinking about the air exclusion.

DR. SAGUES: What is the temperature prediction for the ends of the drifts?

MR. BLINK: It falls off some but it's still substantially above boiling. Not for as long, of course. We have done studies that emplace waste packages closer together out in those regions to try to counteract that as well.

DR. NELSON: Dan.

DR. BULLEN: One of the mechanisms that you identified to mitigate the clad temperature rise was improvement in conductivity with aluminum spacers. Have you looked into through-rod consolidation as a potential way of improving heat transfer out and maybe reducing the number of packages required?

MR. BLINK: I'll throw that one over to Tom Doering, the manager of waste package design.

MR. DOERING: Actually we looked at rod consolidation probably two to three years ago. There are some pros and cons with consolidation in the thermal region, and also if you start failing the rods due to that fact, if you put the rods together, you have interaction with the cladding more and you actually could get earlier cladding failure because of hot spots on the cladding itself.

Studies that have been done. It's a 1.7 at very best consolidation. So what you gain from consolidation is not as good as we anticipated. Therefore we have gone on with the non-consolidated and transferring of the heat this way.

We will talk a little bit tomorrow about the effect of thermal conductivity methodology that we have that benchmarks all those calculations.

DR. BULLEN: With respect to the one to two orders of magnitude improvement in dose to the public that you get when you take credit for cladding and your assumption you have got 98 percent intact clad and if you keep it oxygen free until it's cool that it will hang around, how are you dealing with the pellet-clad interaction problem with respect to volatile fission product gases crossing the gap at the pellet interface?

As we go to higher and higher burnup fuels, 50, 60, 70 gigawatt days, that kind of problem can be exacerbated. So you are talking about failure from the inside out, which is very difficult to predict and a tough argument in the licensing arena. So PCI may end up being a real problem for you and I just wondered how you are going to address it.

MR. BLINK: I think that's one reason why we have considered this defense in depth in the past. We think we are going to get some performance out of it, but we are not sure exactly how to argue for it.

In the last year we spent more time looking at this than I think we have in the last five years. Eric Seegman from PA and Kevin McCoy from the design group have spent a fair amount of time looking at the alternative failure mechanisms besides just creep rupture. Eric has got a draft report out now that goes through them.

I'm not sure if the one that you are raising is one that he looked at, but for the three or four that he did look at they all had less failure than the creep rupture.

DR. BULLEN: There is some data that were published by the Canadians about a decade ago about pellet-clad interaction, and the Skinner report is taking a look at cesium iodide transport where what you will get is dissolution that can go 90 percent through wall, which is not detectable outside, but the through wall 90 percent is gone and all of a sudden you don't have to worry much about creep rupture because it's going to fail by other mechanisms.

MR. BLINK: If that becomes an issue, we are obviously going to have to cut some rods up and look at them to take credit.

DR. NELSON: Last question.

Paul.

MR. CRAIG: I'm going to ask a question which is a little bit redundant but it's to emphasize a point. Your figure 11, the red figure, is really quite fascinating.

[Slide.]

MR. CRAIG: My engineering experience says that when some piece of machinery is in the red zone you ought to watch out. This is really quite a wonderful figure; it really highlights an important point and has the potential to contribute to the transparency of the whole process and understanding what's going on, which, as many people have said, is extremely important.

Clearly, if you can move out of the red zone, you've bought yourself a lot. What I would like to understand better is what the options are that might realistically allow you to move significantly out of the red zone.

MR. BLINK: I have some charts with me which perhaps I can show you at the break that show the equivalent figure for line loading and backfill and low thermal loading and combinations of those three. I could meet with you at the break or after the meeting and show you those. Some combinations give you substantial benefit.

DR. NELSON: Let me ask you one concluding question. Are there any identified negatives associated with ventilation?

MR. BLINK: Dan.

MR. McKENZIE: It's expensive.

MR. BLINK: Dan McKenzie says it's expensive. If you are blowing that hard and you detect something in your sensors, you have to make a decision of slowing down the ventilation and having temperatures go up or being able to handle with HEPA filters that kind of flow rate. That's all preclosure; that's not postclosure. If you are talking about postclosure, it's a different matter.

DR. NELSON: Thank you very much.

MR. BLINK: I think Dick Snell wants to make a comment.

DR. NELSON: All right. Very fast. We're already very, very far off schedule.

MR. SNELL: Additional penetrations in the mountain, which we touched on this morning, are not necessarily desirable. If the benefits are there, perhaps you want to do it, but it's something to consider.

The other things is, once you introduce ventilation as a long-term operational feature, that carries with it a lot of baggage in terms of redundant systems, guarantees that the system will remain operable, that you can handle maintenance issues satisfactorily and maintain your flow conditions while you do the maintenance. I'm not saying that they rule out these possibilities, but they are things to think about when you look at ventilation possibilities.

DR. NELSON: There is also the combinations of active versus passive.

Fine. Thank you very much for an excellent presentation, Jim.

I would like to introduce our next two speakers simultaneously. They are Jack Bailey. Jack is deputy manager for engineering and integration operations of the M&O. We have asked him to divide the topic in two areas to focus the conversation, first on the engineered barrier system and secondly on alternative repository concepts.

MR. BAILEY: Good afternoon. I am going to speak to you today about the engineered barrier system and a series of questions associated with what does it look like, how do we put it together, how do we make decisions. So I will walk through how we are going about that. I'm going to talk VA and I'm going to talk LA. As an engineer, they get a little hard to separate sometimes. So I have a concluding slide to try and bring that difference into clarity.

[Slide.]

MR. BAILEY: The engineered barriers must work in concert with the natural site features. We have been given the site to work with. What's out there, we are characterizing it, we are learning what's in it, what do the engineered features have to do to best work with those features.

Not only best work with the features working in concert -- that's concert, not harmony. Lots of things have to work together. But it also can't adversely impact the natural barriers.

We really have to make sure that we honor the site and that we work with it. If we make a decision to in some way impact the site adversely and its capability of providing a barrier or redundancy or prevention of corrosion or prevention of radionuclide release, we must think through that very carefully.

There was a question earlier for Jim about are all the temperature limits sacrosanct. Well, we are trying to. They all mean something. They protect the zeolites; they protect the clad; they protect uncertainties associated with changes in the wall. We try and honor those. If we have to give one up, it's going to be a very conscious decision and have a very good reason as to why we do it. So it works both ways, with the engineering and the natural.

As an engineer, we don't like to put things into one arena, one thing that is going to make this thing work. Most of us prefer having some redundant systems. I know I fly too much and I'm glad that there are lots of engines on the plane and plenty of hydraulic lines.

So we look at multiple barriers. What are we trying to do with those multiple barriers?

We want to delay the failure of the waste package. The longer we can keep it intact, ala what Jim said, the better off we are. It keeps the radionuclides isolated from the environment.

If and when, since we are looking at a very long time when, the waste package fails, we want to see if there are ways that we can keep them in the waste package as long as possible. Preserve the clad; make use of other materials that perhaps corrode and fill the package and exclude other corroding agents. What can we do to keep it in the package?

Finally, once it escapes from the package, can we do anything to that radionuclide release to slow it or condition it so it will work better with the natural environment? That's what we try and do with the engineers. That's what our job is here with regard to the EBS.

[Slide.]

MR. BAILEY: I will back up for a minute. Because we have to meet preclosure requirements, we have to be able to pack it in some kind of a manner. As Jim said, maybe thermal variability, maybe not; put it into canisters, something that we can handle, something that we can put underground, and something that we can close with.

We have preclosure limits. We have preclosure requirements laid on us by Part 60. They basically take us back to Part 20 for radiation exposure and for accidents or abnormal events. We have to satisfy the health and safety of the worker and the health and safety of the public throughout the preclosure period. So we have to have something that does all that and yet does all the things that I just said it had to do with regard to the postclosure.

So we have to develop a design that provides acceptable performance. Our approach is to go after the expected postclosure case: What is that we think is going to happen in the mountain? What is the most likely set of events that are going to occur? And make sure that this multiple barrier approach handles that.

Then we use additional barriers to improve our confidence in the engineering system for the uncertainties in the natural processes and the uncertainties in the response of the design features. I'll talk about that a little bit more.

We looked at, what do we think the flux in the mountain is? What do we think we are really going to see, and then, how big is it really? Let's make sure we can deal with what we think it's going to be and then look and see what we have to do in order to deal with the extremes or the uncertainties associated with that.

[Slide.]

MR. BAILEY: What are the inputs that TSPA needs in order to perform their analysis?

Well, they have to know the subsurface layout, where is it, what strata is it located in, what is the drift size and spacing, what is the thermal load, the ground support and the ventilation system. What have we put down there and how do we affect the environment that this has to be in in order to have their starting conditions.

The engineered barrier system. They want to know what material is in the invert; they want to know any packing, which is a lower backfill, and backfill which is the upper backfill. They have to know what that material is. And if we have any flow diversion, how we accomplish it and how well it works, for how long.

Finally, the central piece, the waste package. How big is it? What is it's heat load and what materials and fabrication technique is used so that we can do the degradation predictions with some level of confidence?

[Slide.]

MR. BAILEY: As Dick Snell said this morning, this is what we gave TSPA as our reference design at the end of the fiscal year. It's reference design. Doesn't mean that it won't change, doesn't mean that it's absolutely final, because, as Lake Barrett said this morning, we will be engineering until we close. It is an ongoing and evolving process and we have to pick something and move forward.

Further, we are picking something to move forward with for the VA, and the VA case is not necessarily the licensing application case.

I have pulled out basically everything that PA needs to show you here. We have a waste package sitting on a support located inside a 5-1/2 meter drift with precast concrete liner and an invert sitting at the bottom, rock being all this stuff around, showing us down into a water table, if you will, down there, and a mountain up above.

Trying to give us a little pictorial representation.

What do we have? We have a drift liner with normal concrete.

We have an air gap, which is a capillary barrier presumably. It's really in two places. It's both on the mine surface of the rock and it's also on the inside of the concrete liner. We want to take advantage of the fact that the water is likely to run around that barrier rather than drip, if we can show that.

The waste package itself is made up of a corrosion allowance material, a corrosion resistant material. We take galvanic protection should we encounter conditions where it is appropriate to use it. It is a larger package and it is in-drift emplaced, as it shows.

We have a layout of the emplacement drift, which is sloped slightly to the north, as Dick Snell said. We have the pedestal and what materials it's made of. We have the invert, which is located below, mostly for chemical and support.

We also put the zeolites on our chart because our thermal load is present in order to try and protect the zeolites. So we think about what that natural feature is while we do this.

When we come around for the thermal design, we have an areal mass load. We've chosen high, 85 MTU, as Jim

Blink said.

The waste package spacing is what we call point, no end-to-end communication of the packages.

We do enough spent nuclear fuel blending to meet an 18 kW maximum thermal package and to meet our criticality limits.

We have the ability to do waste package sequencing in the emplacement area itself by keeping four drifts open. With four drifts open and two entrances to each drift, we have the ability when a package comes down the ramp to put it in a place to satisfy the loading pattern. Our analysis to this date says that will probably allow us to set up the facility in the manner that we are currently analyzing it.

The thing that I should have started with but I always end up doing last. Over here you see the four symbols: limiting the waste package environment, which is the star; as robust waste package; limit mobilization; and the radionuclide concentration reduction.

Those are the same that Steve Brocoum talked to this morning in terms of the waste containment isolation strategy. We look at the design to see how it affects the waste containment isolation strategy and what's there, and that will come up again in a later slide.

[Slide.]

MR. BAILEY: We clearly have some assumptions and some uncertainties for the reference case. We're not done. We don't have the licensing case and we don't know everything that we probably need to know at this point in time.

What are the ones that are associated in the drift area, in the engineered area where we can work?

Seepage, how much seepage, where.

Waste package surface relative humidity/temperature time histories, as Jim Blink talked about in terms of the heat pushing the water away, letting the water return and getting that humidity back in. All predictions.

Waste package degradation. We have this corrosion allowance material, galvanic protection, and corrosion resistant material. The question was asked, are we doing something to make these better? Yes, we are. We are also looking at the materials to make sure we have chosen the correct materials for the VA.

Radionuclide solubility. Once you get into the package and you are trying to prevent its release, how does it really corrode inside the package? Is the clad there? Is the clad not there? How does mobilization occur?

Transport through the waste package. Is it advective? Does it flow through or does it move through diffusion? Trying to come up with the proper assumptions and the proper ways to model that that are realistic so that we have a handle on what we really have to do.

Finally, how we transport through the invert. How does it actually get into the natural environment again once it leaves the engineered area?

These are big uncertainties that we have to work with and those are what are on our screen for the VA so that we can try and make use of experts or the use of existing data or perhaps additional testing if we can get it done in the time frame and identify that for follow-up action to clarify or solidify what we have chosen to do.

[Slide.]

MR. BAILEY: Let's go to the options and then we will come back to the assumptions.

These are the options that Jim Blink talked about. We chose these. You will see that there are three of these charts in here and they grow. Each time there is yellow it's things that weren't on the chart before.

The cladding credit, taking credit for the cladding as we discussed before. Once a package is breached, can we retain the spent fuel inside the clad or is it released fairly quickly?

We are looking at a ceramic coating. Can we coat the outside of the package? Can we push the heat through it? It provides an alternate barrier to the metal, a different failure mechanism, a different way to protect the package, and it does a number of things for us.

We are looking at a drip shield, which is essentially a ceramic device as well, but instead of being attached to the package with the inherent problems of going through expansion and contraction and getting it to adhere, this in fact would lay on top of the package.

There are crevice conditions, obviously, but this would lay on top of the package and prevent drips from falling directly into the package or onto the package and make release from the package tend to be more diffusive, which is a much longer time frame and helps us a great deal in terms of release from a package as it ultimately fails.

Finally, backfill which we put in there both for rock fall protection so as to protect the ceramic liner or a drip shield, should we put one in, so that we can get a high confidence that the conditions in the drift after closure won't cause those to fail.

And limiting of the flow and the humidity. The backfill tends to keep the salt off the package and tends to keep the water away from the package. We believe because of the heat it forms a barrier. That gives us some help.

So those are the four options that we are reviewing for the viability assessment, and our intent is to have those done to about the same level of detail both in the performance assessment area and in the design area as the reference design so that they are available to us.

[Slide.]

MR. BAILEY: If we go back to what our assumptions and uncertainties were, you can see that I have chosen them and listed them again here, and now we have taken a look at the options and how the options help us with the various certainties.

In other words, how can I deal with the fact the seepage into the drifts is a bit uncertain? How big is it? I don't know exactly. But if I go with ceramic coatings or drip shields or backfills, that uncertainty is not quite as interesting to me, because now I have something that if I can get some certainty in an engineer design, then I can take the uncertainty associated with that seepage out of the equation, or at least account for it in a different manner.

The same is true for seepage onto the package, the drift thermo-hydrologic response, the degradation. You will notice I put "alternate materials" here. Although that isn't one of the options, it is something that we are looking at prior to actually closing out the VA design; one last look at the materials to see if we have the best materials that we can defend.

Radionuclide solubility. We want to look at the cladding.

And the transport through the waste package, the drip shield.

The transport through the invert. I chose not to put one on there. You could make a drip shield that is so big that it skirts the entire waste package down to the invert, but we are not looking at that real hard right now. So I chose to leave that one out.

So those are options that help me with my uncertainties, and those are both natural uncertainties and engineered uncertainties, but it layers another type of a design that can help me reduce what I don't know about my system.

[Slide.]

MR. BAILEY: We have to be fair. There are uncertainties for the options.

The cladding. As Jim described it briefly, it has various failure mechanisms: Does it pinhole, unzip? Mechanically could it break? Could we have rock falls and break the packages at a time late in life? Or maybe we want the rocks to fall and bridge and become comfortable while the package is still very robust.

And what are the initial conditions at emplacement? In regard to Dr. Bullen's discussion, do we really know what we are putting in there and how long it's going to last. We have to think through how to handle those.

Ceramic coating:

Long term permeability. Will it really keep water off the waste package? That we ought to be able to figure out.

Mechanical integrity. Again a test that should be runable, that's demonstrable for a long period.

And we need to look at the failure modes. Those are a little harder in the long term, but what are they?

The drip shield:

We have a waste package interaction, the gap question, and all the ceramic issues.

Backfill:

We have to look at the thermal conductivity. Do we ventilate before we put backfill on to satisfy the clad? Do we wait a long time? Do we age the fuel before we put a backfill on? So we have to worry about the thermal conductivity. Or can we find that really transmits the heat well?

Finally, seepage and wicking. What really happens because the water falls on it? Or does it draw water up from below?

I want to give an even treatment to those, but we think we can solve most of those questions on engineered features. We think we can come up with answers on those.

[Slide.]

MR. BAILEY: If you go back to the strategy, develop design features for the expected case. What do we really expect to see? Let's make sure that case can be handled.

Systematically evaluate options for the design features to improve performance:

Use the performance tools. Those include the performance assessment; they include the things that Jim Blink talked about, a variety of tools in that regard.

And evaluate the sensitivities to the low probability events and scenarios. How do we deal with those and what is the result? Maybe it's low probability; maybe it's low consequence. If it's a high consequence, then that's a different consideration.

Then, finally, go through and evaluate the performance sensitivities for data uncertainties and document the features that help you with that.

[Slide.]

MR. BAILEY: And then look at the performance. How do we think the engineered features are going to behave? Look at what those tradeoffs are and what we don't know, and document those.

Finally, once we know all of them, select the appropriate design features to satisfy an expected case and how we chose to deal with the sensitivity or the low probability cases.

[Slide.]

MR. BAILEY: How do we do that? If you've got one, let me know. Lots of ways to skin this cat; lots of things we can do.

Are all of them as effective as all the others? No. But there is something there and it can have an effect on performance, sometimes a good effect, sometimes a bad effect. We have to walk through them.

What else will we pick up? All the way to the surface control. Can we withdraw the land everywhere this is going to go forever? Probably not.

Infiltration control. Can we plant trees, put the alluvium on? Could we cover the top of the site and lower the amount seepage, lower the amount of percolation flux? It's something to think about.

Change the pH of the concrete for chemistry reasons; different kinds of concrete. If concrete doesn't work, we are actually doing a design such as steel sets could be used without concrete. If we find concrete is such a problem, we'll be prepared with a design to show that the facility is viable with steel sets.

We have the crown joint and the no crown joint, which is where do you put your joints? On the vertical? Do you put them above the waste package or do you make the top piece into a long arc so that it runs all the way past the waste package so if you have mobilized water during the time when the support system is in place you can keep the drips off the top of the package?

Ventilation, both preclosure and postclosure. Is there something that we can do with ventilation?

Filler material as a way to exclude water, maybe for criticality, maybe for preventing the radionuclides from getting out.

Small, small-in-large waste packages; different kinds of waste packages.

Vertical boreholes, horizontal boreholes. Maybe the repository should be level. It probably doesn't matter.

We can put some additives in the invert, put some sorbers or something down there. We can put things in that will capture the radionuclides perhaps, or slow down their transfer.

We have restricted and non-restricted, meaning those things which restrict human access or don't restrict human access. Some are benign to us and some of them we might not necessarily want to be around without protective actions.

The backfill can condition water and sorb releases. We could mix it in there. We could have different kinds.

I alluded to this. Here is a drip shield, free standing and, if successful, it will keep advective, it will keep flow and make it diffusive everywhere inside the waste package, the one I described. Then my bat wing is suspended inside the backfill, which takes away all of my gap issues but is very difficult to install.

Different kinds of backfill. Also hard to install anything other than a single layer, but you could. We could put in different layers if we thought that was helpful and create a capillary barrier inside of the backfill.

We can lag storage if we had to, surface and subsurface. Currently not part of the program, but if we felt that was necessary for thermal aging or blending, it's there as a consideration.

Controlling thermal variability, as Jim Blink suggested. Low thermal load or a line spacing.

In addition, we can work on the drift wall, grout injecting to fill in voids and perhaps seal this better. And then perhaps there are some altered near-field rock that goes on where we create some mineral caps that might have flow control or structural integrity for us in the long haul.

Those are things we are looking at. As I say, if you have some ideas, we'll certainly give them consideration.

[Slide.]

MR. BAILEY: How do we do this? If you go back, this side is everything that's on the charts.

Up here are our postclosure goals: delay breach, keep it in the package, try and catch it once it gets out.

Postclosure environments. There are a lot of things that can go in this column. I chose environments. That's the flux, and it's supposed to be water. Water flux, relative humidity, chemistry, rockfall and drift collapse. You could put uncertainties in there; you can put in performance; you can put in cost.

There are lots of things out here to consider. When you start making these matrices, you find out that the corrosion allowance material does a good deal for that. It helps there, it helps there, and these are the things it works against. So you can start seeing how much do you get out of each type, i.e., there are lots of them, what do you really get in terms of performance. There should be a performance column. This doesn't show numbers. An X and a Y. There is no gradation or criteria other than major or minor.

But then you can start looking vertically.

Do we have a lot of ways to prevent the breach of waste package?

Do we have a lot of ways to mitigate? Not really as many.

Do we have lots of ways to deal with rockfall? Not really as many.

So we can start looking at the different ways and different means by which we can do the design, and we document it and show it.

[Slide.]

MR. BAILEY: There is a second page for completeness.

That's how we are going about it. I have mixed, putting together an expected case with a defense in depth case, which would be a licensing case.

[Slide.]

MR. BAILEY: EBS design development strategy. I have a top of the chart VA design focus and a bottom of the chart LA design focus.

The VA design focus is to work the expected scenarios and perhaps a standard deviation on either side so that we are working into the right area, and we'll include variability. Not only uncertainty, but variability.

From that we will come up with what we believe the EBS reference design will perform.

We will then take the various options that I described, the clad, the backfill, and we'll add those on, singly or synergistically, and identify that we have the capability to suppress the dose even further should we chose to make those kinds of decisions, and with the type of chart that I just showed you show that we have the ability to deal with some of the sensitivity cases, and we will do just a limited set of sensitivity cases for the VA.

For the LA we will sample, for the most part, the whole probability range. It will probably be truncated a little bit at either end. It hasn't been decided how much or where. That is dependent, frankly, upon the parameter of interest. But we will basically sample the entire scenario range with the entire design, both the reference design and the EBS, and we will come with what we believe the entire system will perform on an expected value basis.

We will then do some low probability scenarios of those low probability high consequence, and will at theirs to do an evaluation of how important or what contribution to dose could that low probability scenario have, and we'll look to see how that works out.

It may come out under the regulatory standard; it may go above the regulatory standard. This slide is not making a commitment to stay under the regulatory standard in that case. It's an evaluation of what is the event, what is it's likelihood, and what does it really cause in the way of a problem.

DR. NELSON: Thank you, Jack.

I would like to open it for questions from the Board dealing particularly with these engineered barriers that are contemplated on the reference design as opposed to the next discussion, which will be the alternative repository concepts, which are a little bit more radical changes from the reference design.

Are there any Board questions for Jack Bailey at this time?

DR. BULLEN: Jack, in light of the waste package degradation expert elicitation and their somewhat lack of endorsement with respect to ceramic coatings and galvanic protection, can you comment on your estimate of the likelihood that those will actually have an impact on the alternate design concepts?

MR. BAILEY: Yes. I'll be happy to. The expert elicitation suggestion that the galvanic protection might not be as effective as we had believed because the mechanism of corrosion is probably expected to be a broader spalling general corrosion than a deep pitting corrosion, as we were previously modeling. There are times in the life of the package, especially with the concrete present, that we may in fact be seeing pitting.

Our intent is to continue our testing and continue our evaluation of the galvanic protection, because we do believe that it can prove effective, and to use it at the appropriate times, when a couple processes say that it may come into play.

We are continuing with the testing. We built the bi-metallic structure last year, and we are cutting it up and putting it into the tanks to test. So we will go through and do the testing and have a good basis for it.

As I said, if we can show that that works, then when a couple processes say that it should be invoked, it probably will be. It, however, will not have the stature, if I can use that word, that it would probably have from the TSPA-95 model where the corrosion of the package was driven very heavily by pitting as opposed to a general corrosion.

With regard to ceramics, I guess it's who you ask. Ceramics people tell us it will work real good and you can attach it and it will stay real nice. A lot of metallurgists say that it won't. I don't know if it's turf or if it's understanding of different mechanisms.

We are putting in place and are in fact about to test some ceramics to look at exactly the three things that I said, the permeability; its mechanical resistance, which is frankly third on the list because we can protect it; and then what its ultimate failure mechanism it.

It may very well be that a scratch or a crack in the ceramic may merely -- I say may -- cause corrosion at that point as opposed to a falling off of the entire ceramic.

Our intent is in fact to do some testing. We are going to elicit some experts to see what they think is possible, and we are going to proceed with that course until we disprove it.

One of the problems that we have is a great deal of anecdotal information: don't go work on clad; pellet/clad interaction, PCI. Can it really work? Well, we will go find out if it works or not and we'll write it down and we'll document it and have a basis. We can do it or we can't do it.

The same thing is true for ceramics. We'll go document it and we'll test it. If it doesn't work, we're not going to use it, and if it does work, we are going to use it.

I'll just flip back to my chart here.

[Slide.]

MR. BAILEY: We have to do that. That's everything that can happen. We've got to go figure those things out and say yea or nay and decide whether they are meaningful, whether they are not meaningful, whether they help us, whether they hurt us. Once we do that, then we will start making decisions. We have to be reasonable and prudent in our actions and we have to understand what all the things are that we have to work with.

For the VA, we can't get all that done. We have a pretty good idea about the things that we are working with. We have worked with them for a number of years; we know what our weaknesses are and we know how to go after them in a short term to shore them up and say can we or can't we. This is a longer term. We have a couple of years, and we've got to go through this. There isn't another way to do it for the design path that we are on, not to dissuade the alternatives discussion we are about to have.

DR. NELSON: Alberto.

DR. SAGUES: I guess the most interesting part of the presentation for me was the design features evaluation matrix, which is basically a way of making a decision, trying to take out some of the options and commend the others.

My question goes is this. Who is going to do the tally and fill in the blanks and cross things off as better and not so good? Do you have a provision for two different groups or three different groups going through the same exercise and then seeing whether they actually happen to agree with each other? Do you have any way of introducing some element of eliminating bias or preferences that may already exist?

MR. BAILEY: Our intent is to evaluate the chart.

We are going to be way beyond X's and O's pretty soon. We have to get real numbers to put in there. That will be done through PA tools; it will be done through the work that we do in the design basis modeling inside of engineering; it will be done from science. They will provide all those inputs into this chart so that we have hopefully not that much bias.

I will add that we have a repository consulting board who has expertise in the engineering areas. We have a TSPA peer review committee who has expertise in a number of areas. We get to meet with you folks periodically. So we certainly get to see some other opinions. And we have an obligation to make sure that what goes in here is in fact as true as possible and it is not anecdotal and it is not what Joe wants to talk about or what Joe thinks is true. We have to get that bit of objectivity.

The other thing, which Dick Snell alluded to this morning, is that we are going to control the design. I can tell you exactly what PA has as of the 30th of September, and it can't be changed unless it goes through a process that Dick Snell or I say it can be changed. It can't be changed. Nobody can change it except us, and I expect that my management and the owner is going to be very interested in anything we do that changes that.

So as we built this chart and as we recommend low thermal loads, changes in materials, addition of ceramics, all that has to go through the system, and it has to go through the system based on performance; it's going to have charts for what are the uncertainties and likelihood of success, what is the cost, how does it fit with the rest of the system.

That's why I make the big chart, because you don't want to work on that one in isolation; you want to look at everything. If I've got all those ways to keep the thing from getting wet, maybe I don't need to find another way to get it wet; maybe I do. We want to put all that information in front to make those decisions. It is a first of a kind and it is sometimes hard to do.

Yes, sir.

CHAIRMAN COHON: Just to follow up on that exact point. Suppose you had that matrix all filled in with the numbers that you want and suppose they were objective even, and suppose you had all the other information you mentioned. How would you go about deciding? How would you chose which options to implement or include in the design and which not to?

MR. BAILEY: First you have to know what your standard is, what is it that makes you acceptable. That's a number, what dose to the public and at what distance from the facility and what time frame. That's first and foremost.

Second, you have to be able to provide a reasonable assurance argument to the NRC.

Third, you have to look at that reasonable assurance argument and decide is the reasonable assurance argument such that by evaluating the uncertainties that there isn't a pop-up that is going to move the whole thing away. In other words, the defense in depth approach.

With those three things you can start making your decisions.

Have we written our criteria for that? No. But that's the process that we have to go through, and I believe those are the three factors that we really have to consider. There is a fourth factor, which is cost, and we have to look at what the cost of all of these items are.

CHAIRMAN COHON: Yes. You said before cost is one of the things.

MR. BAILEY: But we absolutely have to understand the performance and how well it works, and then we will work with the cost issue.

CHAIRMAN COHON: I was thinking also, though, in terms of method. This thing sort of cries out for the application of some kind of decision theoretic approach. This also goes to Alberto's question, that if you had some methodology that you could use to turn the crank, it would give you a way also to try different subjective views of the competing factors relatively easily.

MR. BAILEY: Yes. I would agree with that. It isn't intended to be three people sitting in a dark room.

DR. NELSON: At this point, are you ready to move on to the next subject?

MR. BAILEY: Yes.

DR. NELSON: Here's our next speaker.

[Slide.]

MR. BAILEY: In the previous talk, we reviewed the EBS design, what we think we have to do to satisfy an EBS for the chosen basic considerations that we have at this point in time. It's an economical design that we have chosen. It puts lots of waste into a few packages; it loads the packages into the repository in a manner that saves us as much space as possible and minimizes our construction.

The performance assessment suggests that we aren't doing too badly with the design that we have right now. It's what provides us a basis to work. Everything that I talked about was a process and what we know right now should we take the VA design to LA.

This talk is about alternative designs. Let's get out of the box; let's do something different, something a little more radical.

Perhaps the way that we chose those is to try and do away with some of the uncertainties that we have encountered because of what we have chosen. The high thermal load and the effect on the rock and how the water moves is a good example.

[Slide.]

MR. BAILEY: There are four that are of particular interest, I think.

Thermal loading. There are a lot uncertainties with the thermal loading. We will move a lot of water. We are doing a lot of testing to find out how that water moves so that we can bound it. We are coming up with engineered features to deal with that uncertainty because we may not know exactly how to resolve all of it, but if we can get engineered features like ceramics and backfill, then we have a chance of staying away from those particular uncertainties.

The waste package size is always of interest. How big should it be? Should it be economical sized, or should we make it much smaller so that we can spread the heat out or spread the radionuclides out? That is, of course, related to a certain extent to thermal loading and certainly to the thermal goals that Jim Blink talked about.

Ventilation is of interest because there is a mechanical thing that we can do, a mechanical approach that talks about the control of the heat, again staying away from the uncertainties associated with heat. And the potential removal of moisture both in the preclosure case, if we ventilate for the 50 years, or for a long time should the repository stay open longer, or the suggested natural circulation of a closed repository that Dr. Danko has suggested, or an open repository. Just keep removing the moisture. Moisture is the enemy. Don't let it corrode the package. So keep it away.

Finally, the questions of human access to the repository. Should we be able to go in and look at the rock to see how it's really behaving inside a drift?

Probably more importantly than that is the ability to deal with upsets in the placing of packages or as packages are in their resting place to avoid the remote handling issues, which as an engineer I think are completely handleable. Being able to go in there and see and touch and be closer to upsets provides that ability to have a little higher confidence that you can deal with them.

Those are what we chose as the big four alternative design features to give some consideration to.

As Jim Blink said, we have done some work this year and a study which we haven't issued. The reason we haven't issued that study is that we are still looking at the results with regard to what conclusions we can draw from those results.

To go back to Dr. Sagues' comment, we want to make sure there are no biases and we want to make sure that there is a pure basis for why we make these choices. The choices are probably not design decisions at this point in time. We probably don't have enough fidelity in our calculations to be able to say it's low thermal load time, but we learn something about as we move through.

[Slide.]

MR. BAILEY: In the interest of time, we did look at three different package sizes represented by the 21 package BWR. Tom Doering will talk a lot about the sizes, I think, tomorrow; the 12 size PWR, which is about half that many, so you have a little source term and a little less heat; and the 5 PWR, which is a very small package.

We looked at them with and without shielding. What are the thermal effects? Can we shield them? What physically happens because you want to shield this?

We looked at an 85 MTU per acre, which is the high end, and we looked at 25 MTU per acre, which is the load thermal load area.

In the 25 MTU area we actually did two pieces. We actually looked at allowing boiling above 100 C in a rock and how would we do it to not let the rock get to 100 C. What would we have to do to not cause the rock to go through the boiling? Not going through boiling doesn't mean there aren't geochemical effects, but you do limit the boiling of the water per se.

Then we looked at various ventilation schemes. We tried to do combinations and permutations of that. I'm going to talk just a little bit to that today.

We looked at the physical parameters; we looked at the things that we could really measure, the temperatures, the sizes, the mass, the cost. We tried to look at those items with it, keeping a skewed eye to the performance aspects of them.

[Slide.]

MR. BAILEY: We did a preliminary analysis of the alternative designs. That's what we are doing for VA. We are focusing on the VA design. It is important that we develop that VA design and be able to make the management decisions that Mr. Barrett talked about this morning.

While we are doing that we will work and try and understand what are the important aspects of the various alternatives.

How do we improve the fidelity of our models? What is it that we have to learn in order to -- I like the word "calibrate; the PA guys don't -- calibrate those models so they'll work at high thermal loads and low thermal loads and different corrosion areas and different temperature regimes? We tend to focus testing on those areas. We want to make sure that we have an apples and apples comparison when we finally get down to it.

We are pushing for the VA design and we are doing scoping or small studies, one of which is being completed, with regard to the alternative designs.

For the LA we pretty much have to have a full treatment of the alternative designs. That's required for the license and Part 60, and we have to be through that to an extent that we can explain why we chose what we chose.

In the coming year it's important that we stay focused on the VA and that we look at the alternatives and how to get specific performance out of those alternatives for the future.

[Slide.]

MR. BAILEY: Jim Blink went through the thermal goals, clad, drift wall rock, zeolites, and there is an at-surface which he mentioned briefly and a couple of others.

We have below 40 and above 40. This is where the boiling isotherm coalesces down the drift. As I said, we also looked so that there was no boiling.

Some good guy numbers. It takes about 10,000 waste packages to place at 85 MTU per acre and a 28 meter drift spacing and about 740 acres.

At 25 MTU per acre you are down to about a 56 meter drift spacing, and it takes between 10,000 and 16,000 waste packages to accomplish it, mostly because of the heat.

CHAIRMAN COHON: Is that drift spacing drift to drift?

MR. BAILEY: Drift to drift, yes. I'm sorry. It's drift to drift in the block.

The more interesting number to get down, it takes about 2,520 acres. It takes almost four times as much space to emplace, which makes sense because it's more than a third reduction. So it takes a great deal more space in order to do that. As you might expect, cost goes up as you start to excavate and need to characterize greater portions of the facility.

If you go to the no boiling case, it's pretty much five packs of fuel for the PWR. You have to age the hot packages about 20 years more than they already are before you can put them underground, and it takes about 33,000 packages, about double the number of packages for 25 MTU per acre, which allows boiling.

So when it comes down to strict numbers, we have a pretty good idea of physically what it takes. We can show you those numbers when the report is issued of how much it physically takes. The cost becomes pretty clear.

The considerations: mobilization of water, geochemistry, structural effects, and it shows 50 kilometers of additional tunnels. It's probably a lot more than that when you start taking into account how you get there.

So we have a pretty good idea on the physical handle.

[Slide.]

MR. BAILEY: But then you look at the total system performance. Okay. Now we've got the money, now we know what physically has to happen. That's all very interesting. Do you get anything for it? Does the place work better? Is it something we should be doing?

Those competing effects. You want to move the moisture away and you want to keep the moisture away. The hot packages seem to do that better, as you might expect. It tends to boil it and have the energy necessary to move it away. As such, you would expect it to stay away longer to percolate back; colder you would expect it not to go as far and come back sooner.

The kinetic effects of temperature on the corrosion of the corrosion allowance and the corrosion resistant materials. One of the other pieces that came up in the expert elicitation was that perhaps we have too much temperature dependence in our change in degradation rates; perhaps the rate doesn't change as much as we believe it is.

We have a fairly steep curve which we elicited a couple of years ago, and we have got some test data now that says maybe it's a little flatter, so maybe you don't get quite as much effect from temperature, lowering the temperature, on the degradation of the packages as we believed. On the other hand, galvanic protection changed. So where we used to work with pits, we don't work with pits.

The study that will be issued soon was done with TSPA-95 calculations, which are changing. The testing that we are doing thermally in the field suggests that we need to calibrate our models a little bit on how the water moves. The expert elicitation has suggested we need to calibrate how our metals corrode.

We need to put those couple processes together to get the time histories, the movement of the water, and put all of that together into the couple processes. Jim Blink's trajectory chart, as we call it, his red and green chart is going to change. Those things are different. So we think that's probably going to change now. The humidity may change; the areas of corrosion may change.

Of course his didn't go into the mechanism of corrosion, just that there was corrosion. Before we looked at that trajectory chart it came to a certain point and then galvanic kicked in, and you could then hold it for a long time. Now maybe galvanic doesn't kick in, but maybe it corrodes slower.

There are too many things to try and go "that's the answer, let's move forward." So we have to calibrate those models, and that's what is happening. The models are being updated for the competing effects, and we are working through those.

You will notice in there that it suggests potentially improved performance from the low thermal load. The calculations on TSPA-95 runs say it's a big deal; you get a lot of improvement at low thermal load; it works a lot better. But it's hard to say that that's true or it's not true based on our better understanding of the natural systems and the response to the engineered material.

What it tells me, and I'm trying to be consistent with before, is that we had better look at it again. Once we get these models updated, there is something here to be considered. We don't know what the answer is and it's not time to change, but we certainly are finding out what we need to focus on, and we need to focus on what happens at these lower temperatures and what happens at these lower thermal areas inside the rock system.

[Slide.]

MR. BAILEY: Alternate waste packages.

The design considerations are corrosion resistance, thermal output, being able to handle, and emplacement and the cost. The engineers tell me that 65, 75, 80 tons is probably as much as we can reasonably handle underground. We are into a different technology perhaps if we have to get a lot bigger than that. So we are kind of there. Anything is engineerable, I believe, but that's kind of where the no-lab coats is right now.

The corrosion resistance. Well, we have to be careful of radiolytic corrosion, as you might expect, and general corrosion, and we are trying to pick the right materials to make sure we get the right materials in there.

The thermal. As I just described, we can move it around, or we can age. Aging isn't in the program at this point, but if aging turns out to be the right thing to do, then we can recommend aging.

The current design considers five basics:

The 12 to 21;

44 BWR assemblies;

The 4 to 5 DOE high level waste with DOE spent nuclear fuel as part of that;

Canistered commercial fuel, the NPC;

And canistered Navy spent fuel.

Those are all the things that we look at that we have to deal with.

So we are taking a look at, as alternatives, how about something smaller, the 5, the 12, the 21, as I suggested, going all the way down to a 5.

[Slide.]

MR. BAILEY: And shielding it. We did some work on shielding with A516 using depleted uranium and some magnetite concrete, concrete with some steel in it to act as a shield.

As well as aging. How long do we have to store it to get the dose down?

Lower thermal output. We can look at a smaller package; we can look at aging; ventilation, short term, long term.

And, of course, aged fuel again.

[Slide.]

MR. BAILEY: Preclosure ventilation. We looked at a current design, which is a 0.1 of a meter per second flow through the drifts to make sure the air is moving in the right direction if there is a radiological event.

An alternative was 10 cubic meters per second through the drifts. As Jim Blink showed you, 10 cubin meters per second will make a 50 degree centigrade max drift temperature at the end of the drift; it's 26 at the entry end and 50 at the center. So you can go in and you can go through.

We looked at heat transferred to the natural system.

Our analysis said the heat isn't in the natural system. We start from a cooler temperature.

What happens to the moisture in the near field?

Again we looked at the cost, the cost of putting in that big a system, and then the operating cost of it for a number of years.

[Slide.]

MR. BAILEY: It was alluded to and my engineers are a little unhappy with me because this is pretty notional; it's not a good economical design at this point, but I thought it was useful to show that you have to have a lot of intake shafts and you have got to have a lot of exhaust shafts in order to keep the temperature down so that people can actually go in and work in those areas as they are exhausting.

There are a lot of shafts to dig and a lot of extra drift work to do to move the ventilation around. Not that it can't be done, not that it's unacceptable. It's a question of the gain in performance versus the cost and does it do for us.

[Slide.]

MR. BAILEY: Postclosure ventilation I won't say too much too other than there is natural convection; it could be human induced and controlled, i.e., something from the outside.

The considerations are feasibility. You've got to make those drifts stand up. Somehow or another we have got to be able to keep the circulation path open. I haven't figured out how to keep the emplacement walls up forever, so I don't know if I can do this, but it's a consideration. It is in a different thermal regime and it may be an easier chore, but we have to consider that; we have to consider the human intrusion issues.

But it does remove heat and humidity, as Jim Blink suggested.

[Slide.]

MR. BAILEY: I like things without moving parts. It says it might work and it says it might give us some benefit. So it needs to be looked at. And it's the same picture that you saw before with the same flow paths.

[Slide.]

MR. BAILEY: Finally, human access. I've talked to it a little bit. Ventilation of 10 cubic meters a second to get it so that a person can go in and live there or walk through.

The 21 PWR package has between 100 and 200 REM per hour gammas on contact, 1 to 4 REM neutron on contact, unshielded.

We allow 200 degrees C in a drift. As I said, we can get it down to 50.

So we did some looking at the shielding it would take. I'll run through it very quickly, although the report does a nice job of it.

We basically looked at what it would take to get down to 2.5 millirem an hour, allow 2,000 hours per year access for your 5 REM total dose. Just a flat division as a way to really get it down to small.

What we found is that you needed about 100 centimeters of A516; you needed a whole lot of steel; you also needed a whole lot of depleted uranium; and both packages became unwieldy, in excess of 100 kilograms if you maintained the same package size that we have now. It was just unacceptable.

We then look at the 5-pack. Let's say we go to the 5-pack, or the no boiling case if you prefer. It requires about 100 years of aging in order to put concrete or depleted uranium on it. It will still fit inside the 2 meter size that we have right now, meaning it's handleable, but it takes about 100 years of aging to cool it enough so that you won't exceed your clad temperatures by the time you get it shielded.

Very difficult to show the shielding. The reason is that when you have the big package, the inner elements are pretty much shielded by the outer elements. So all you are seeing in the package is the outer elements for your shielding. When you make the thing smaller, all you did was take away the self-shielding from the stuff in the middle and have to put it in another package and shield it separately.

So shielding is not sitting real high right now. You might he able to go in and walk around, but you won't be able to see the package. It pretty much has to be encased in a foot and a half or two and half feet of concrete. So you won't be able to see the package.

Right now we haven't found physically that shielding is going to work very well if we are going to try and get down to that low a value.

[Slide.]

MR. BAILEY: I'll go back to the first slide for alternative design features, the four. We think we have to look at them.

There may be performance gains from thermal loading; there may be some performance gains from the size of the waste package. Certainly some cost, but there may be some performance gains from the size of the waste package. We have found in the analysis that there wasn't a whole lot of difference between the 5-pack, the 10-pack or the 21-pack. It really didn't make a lot of performance difference. It was mostly based upon the areal mass loading. That's what really drove the issue.

That's what the first piece has shown us, but we will continue to look at package size, mostly with regard to the individual heat of the wall and whether or not the wall and localized problems create a problem for us. Thermal blending may be a better answer than waste package size.

With regard to ventilation, we are going to continue to look. We may need backfill; we may need ventilation in order to accomplish backfill alone; and ventilation may in fact provide us with a significant performance change by taking moisture out of the rock. We don't know, but we are going to go look to try and calibrate our models to accomplish that.

Finally, human access to the repository. The shielding question is making that a little more difficult, but we can get in their for the ventilation aspect.

We did spend a few minutes looking over old work done on borehole emplacement and a lot of rock questions associated with the temperature there of drilling all the holes and putting the package into a tight fit.

We are trying to think of some alternative designs. There is one that suggests a waste package sitting in a trench. Build a concrete trench up above, put the waste package in there, and you can get enough shielding in the concrete trench so that you can walk around underneath and inspect the rock as an alternative perhaps. I'm not sure how much that gains you in terms of human access because you still can't see packages and you can't be around them. But we are looking at some of those kinds of pieces.

What I am trying to say as I stumble through the end of this is that we haven't closed these things. We have learned a lot more about it. We have taken the anecdotal stuff of how many packages do you have to have and how thick is the shielding. We are getting that math done, and now we have those things as facts in our quiver, and now we can go after the performance aspects that need to be worked on.

That's what we are going to be doing in a limited manner this year and certainly fairly whole hog as we proceed to the LA.

Thank you.

DR. NELSON: Thank you, Jack, for double duty. Appreciate it.

Let me ask you one question. I was struck by the drawing that you had up there which was effectively the current repository or the VA repository with a bunch of extra tunnels and shafts in it. How much are you going to reopen all facets of the design? I suspect that there is a design for either passive or active ventilation that might be more efficient in terms of developing the capabilities of ventilation than that particular one.

MR. BAILEY: I would agree with that. As I said, my engineer was a little amazed that I bothered to put it in. I asked him what it would take, and that's what he did for me. I tried to represent as that to you. I'm not trying to tell you that it's horrendous, but you do have to move a lot of air, and there may be better ways. The question is one of performance. If that performance says we get something, then we will go very hard after the design to come up with the most economical design.

DR. NELSON: But it's sort of hard to do some of these things that do represent alternative repository concepts along the line of the existing layout. In some cases it doesn't make a whole lot of sense.

MR. BAILEY: That's correct. We may have to reconsider that. One of the interesting things that happens in the performance assessment world -- I'll see if anybody shakes their head at me wildly -- is that you model in the performance assessment world.

You don't necessarily have to have a pure design in order to model. You can do some parametrics to find out what do I really get from this. The secret is to calibrate it. The guy who did ventilation effects for us never saw that. We told him what we thought we could accomplish with ventilation and he plugged it into the PA and then he gave us some thoughts as to how that was going to work.

The concern we have is that the testing and the metallurgy and some other things are not as high fidelity as we believe they would be in another few months. It's changing. It doesn't mean it's changing down; it doesn't mean it's changing up; it's just changing; and we need to put those couple pieces together.

It was good work, and now we are a little smarter and we know how to put it together better. So we can do things in the alternative area by having the PA guys do some modeling. We can come up with a basic "what is it we are trying to accomplish and what are the criteria?"

If you noticed, I tried to talk a lot to criteria. Jim talked a lot about what are numbers and where these things are. I tried to talk to criteria and what we are trying to accomplish. If we can stay with what we are trying to accomplish, then we will start picking some numbers and say, can we do it. So we find out from PA, do we get anything from ventilation, and if we do, then we'll go figure out how to design it. And if we don't, then we're not quite as interested.

DR. NELSON: We'll go to Debra, and I want to open the questions up also to the consultants.

Debra.

DR. KNOPMAN: You just gave me the perfect segue into my question. I realize there is a lot of analysis that is still to be done. If you look at your alternative design features for thermal loading, waste package and ventilation, let's pick one performance criterion, like delaying release from waste packages. Could you give us order of magnitude guesses? I realize that's all they are now, but at least your feel based on what you know, the possible range of gains you get in performance from changing thermal loading, from enhancements to the waste package, and through a much higher ventilation rate.

I'm just trying to get some feel for whether we are talking about dying a few hundred years in the case of the waste package or a few thousand years, or in the case of thermal loading another thousand years or so of dryness.

Do you want to try that?

MR. BAILEY: Sure. First, don't believe that we know nothing. I'm an engineer. So I'll represent me. Nothing is absolute. There is always a little give and take. We know a lot about what goes on inside that mountain. We know a lot about what happens in that metallurgy.

Putting it all together and making it a licensing case -- my background is nuclear licensing in the commercial nuclear business -- we have a little ways to go to make that work. But we have some awfully good understanding and knowledge of what it is that actually is going on there. So don't let me leave you with "we don't know anything." We are trying to make it better before we move forward.

What we found is that waste package size doesn't make a whole lot of difference. You don't change very much with regard to it to say it's mass loading that seems to make the difference. We found that the mass loading did make a significant difference and we believe that it's tied to the kinetic effects of the corrosion, and we believe that the results are tied to the kinetic effects of the corrosion, and we believe that it's tied to how quickly the water comes back, both of which we are looking at specifically in our model evaluation. There was a significant difference between low and high.

As I said, I'm not certain. I think we need to run new models before we know for certain, or at least get a little closer to what is there to get them calibrated properly.

Ventilation just gave you a different starting point. The preclosure ventilation gives you a different starting point. It starts you out at a lower temperature, perhaps removes some water from the drifts. So you start at a little bit lower temperature so your boiling isotherms don't move quite as far and you don't move quite as much water. I don't recall the results from that. I think we did run it, but I don't recall the results. I don't think there was a significant difference.

We did not evaluate Dr. Danko's specific on how to move it. We didn't have an easy way to model that right now in terms of how to move that and some of the feasibility questions.

The only thing that really seemed to make a big difference was in fact the thermal load, and there is some question with regard to the modeling.

The non-boiling case also turned out to be a little worse the way that the models worked. It actually turned out to be a little worse than the boiling case. I can't explain that. I wish that I could. The idea, I guess, is that the moisture is there and it's still hot enough; it's warm enough, it's toasty, and it's dripping.

But I don't know. Again we are into models. I don't want to say no boiling is no good out of this side of my mouth while I say low thermal load is no good out of this side. But we didn't find a significant difference. I think the models are not bad for comparing items at similar conditions, but it isn't clear that they work across broad ranges very well.

DR. KNOPMAN: Between now and LA will you be conducting lab and field studies that will substantially improve your predictive capability on these various alternative design features, or is it all strictly modeling, basically model enhancements or adding complexity to existing mathematical models?

MR. BAILEY: No. The improvement to modeling should be based as much as possible upon factual data from the field, either our testing or someone else's testing, or natural analogues. That's what we should be using. There is in fact a fairly extensive corrosion testing program which Dave Stahl will talk to you about to close out your session tomorrow.

There is testing associated with thermal aspects of the mountain going on in several places around the mountain, which Larry Hayes can talk to at great length. It should provide us some information on how that is going to work better.

Ventilation is a little different problem. That I have to think about. I don't know that there is anything specific other than, I guess, the niche tests which are going on, and they will provide us a good deal about what is going on.

DR. NELSON: Jerry, Dan and then George.

CHAIRMAN COHON: Two quick questions. In all these statements you were just making about whether something mattered or not, that was always with regard to peak dose as estimated by the TSPA models.

MR. BAILEY: Is that a question?

CHAIRMAN COHON: Am I right?

MR. BAILEY: No.

CHAIRMAN COHON: What was your basis for saying that?

MR. BAILEY: I have to go back to my other chart that we all like.

CHAIRMAN COHON: Your matrix?

MR. BAILEY: Yes.

CHAIRMAN COHON: Good enough.

[Slide.]

MR. BAILEY: The matrix says there are more of them. The other thing is you want defense in depth.

CHAIRMAN COHON: Good enough. I got it.

On your chart 10 on postclosure ventilation you listed three considerations. One that you didn't list but you mentioned during your presentation was human intrusion.

[Slide.]

CHAIRMAN COHON: That it's not on the printed list of considerations, do I read from that --

MR. BAILEY: I buried it in feasibility.

CHAIRMAN COHON: Okay. Thanks.

DR. NELSON: Bullen

DR. BULLEN: Jack, I have sort of three quick questions for you.

You said you had to get down to 2.5 millirems per hour so you could have human access. Why so low?

MR. BAILEY: We chose that arbitrarily. The idea was 2,000 hours so somebody could work there and get 5 REM a year. That's why we chose the number. It was arbitrary. We could have chosen it as 30. It doesn't change the results a whole lot between 2.5 and 30.

DR. BULLEN: Have you done the cost analysis with respect to waste package shielding versus the cost for performance confirmation? With all the tunneling above and below, if you've got shielded waste packages, I could stroll down the aisle and inspect and ventilate so that I could get in there. How much does that save me versus the cost of having to put in performance confirmation testing above and monitoring? Has that cost analysis been done?

MR. BAILEY: No, that cost analysis hasn't been done, but the performance confirmation that we area really interested in is what is going on in the rock more so than what's going on in the package or in the drift.

The drift is interesting, but it's lined. There isn't much to see except whether the wall is staying up. We can see that. What we really want to find out is what is going on inside the rock. We want to find out what the temperature is doing, where the water is going, how the isotherms are moving, what's physically happening. I don't know that we'll take samples from that. But we're really trying to find out what is going on in the mountain itself.

Being in the drift is really there more for upsets. If I were choosing a basis, it would be to deal with upsets, not trying to deal with the PC. PC is what is going on in the rock, and I don't have a reason to drill my hole from inside. I'd just as soon take it from above, from the undisturbed area and start poking into the disturbed area to learn about it.

DR. BULLEN: I am a little bit perplexed where you come up with a meter of A516. We can build a dry storage cask that only needs a quarter of a meter for licensing.

MR. BAILEY: Maybe I read it wrong out of the report.

Did I read it wrong, Tom? I probably did.

MR. DOERING: Basically what we are dealing with for dry storage casks and things like that, they are looking at specific fuel types that have maybe a 5-year-old 33 gig burnup. What we are looking at is a much higher dose rate of 70,000 metric tons burnup, something in the 10-year-old time frame, so the gammas and neutrons are coming out very heavily. So we are dealing with a higher dose rate out of the fuel; the source term is higher.

Secondly, we are also restricted from using interesting materials like polyethylene that we normally would use, or glycol that we would normally use. With that you are having to deal with the basic materials which require thicker.

DR. BULLEN: I think the key here is that you should divide up the two radiation doses. If you shield for gammas for one thing and then if you actually have to go in there, you can always take in your polyethylene and put a cover on whatever you need to get to to take a look at the neutron doses. Those are the kinds of things that they do in dry cask storage all the time. They'll take a cask and they'll move it out and then they will put the neutron shield on it. So the only thing you've got for impact limiting is the neutron shield may get destroyed.

I don't want to have to say that you need to do it all in one shield, to put those extra meters of material on just to take care of the neutrons.

MR. DOERING: It's an option that we haven't taken a look at. If that's another operations thing. We can take a look at it. But if you are moving one shield, what's the need to put another in? Now you have two mechanisms you're dealing with.

DR. BULLEN: I just think it's a little bit of a misnomer to try and do it all with A516.

MR. BAILEY: Tom reminds me that we took a heavy-handed approach to the shielding, and that, yes, we could do it and we could probably cater it for specific types of fuels and we could use specific shields if we have a need to go in there. Part of this is what's the need to go in there.

DR. BULLEN: True, but if you are taking a look at the design option for access postclosure or access after you are doing this, you don't necessarily have to take a look at the worst case and then preclude it because you've have to buy a meter for everything.

MR. BAILEY: I understand.

MR. DOERING: Going into that answer and that question a little bit, then you'd have to have a design bases waste package for the many different kinds of waste forms that we are dealing with and how do you segregate that. So it becomes a licensing issue also. Basically nothing is for free.

DR. NELSON: George.

MR. DANKO: I would like to have a question about drift diameter. You presented us a great number of design alternatives. I'm almost dizzy about the many solutions.

[Laughter.]

MR. DANKO: But I am still missing one, so please forgive me for this. My question is whether you feel that the drift diameter could be reduced maybe even down lower than Tom Doering told us, that it was 4.5 or 4.6 meters based on cladding temperature. If you happen to consider seriously ventilation, you could probably come down with the drift diameter from temperature constraints, down maybe to 3.5 meters, or below a little bit of 4 meters.

My question is whether that reduction in drift diameter is compatible with other aspects of waste repository design or if the drift diameter is driven by some other constraints, like construction or other points?

MR. BAILEY: I'll look at Dan here for a minute. I think the answer to the question is that we have a size for keeping the temperature down, as Tom suggested. The ventilation might be able to help with that temperature.

We do have to have a big enough gantry to pick these things up and carry them in. We do not have to be able to carry one over another. We could abandon that if we need to. It's present now. So we are preserving it unless we don't need it. But we do have to have a gantry that has enough steel on it to basically be able to pick this up and carry it. That may in fact be the driving consideration.

Can you help me with that, Dan? Is the size of the drift in fact involved in the size of the gantry?

MR. McKENZIE: This is Dan McKenzie with the M&O. In my briefing we will see a cross section of the drift that shows the liner and the emplacement gantry and two packages imposed one over the other. You'll see that there is not a whole lot of room left in there. That's assuming that we use the concept that we have now. If we went back to rail cars, which is what we had in ACD or something like that, you might be able to change that space a little bit, but for right now with the concept we have the drift size is reasonably tight.

MR. DANKO: When you work on alternative design concepts and also with the shields, you might consider that the smaller drift is better self-shielded. It is more integral in the long-term range, and that would be a great advantage.

MR. BAILEY: Yes. As an engineer, when we choose our design, we are going to make the best one we can. If it ought to be smaller, it will be smaller.

DR. NELSON: Klaus.

MR. KUHN: Apparently Yucca Mountain is located in the unsaturated zone. Nevertheless, one main objective of your design is to prevent water seeping into the repository to prevent contact with the waste package. My question is, have you looked into the international available concepts for repositories which are located in the saturated zone? They have the problem per se; they will be refilled with water after some time. I am wondering if you have considered, as the Swedes, for instance, and the Swiss and the Canadians do, making use of bentonite as backfill material.

MR. BAILEY: I personally am not familiar with those designs. If there is someone here who wants to try and address that specifically. We certainly are staying alert to what goes on in the community, but I personally can't address that question.

DR. NELSON: Carl Peterson has a question.

MR. BAILEY: You want to answer that, Abe?

MR. VAN LUIK: This is Abe Van Luik, DOE. We looked at bentonite and decided that there are a couple of properties that in the unsaturated zone give us a problem.

One is that they would imbibe water and therefore create a wet environment around the waste package.

The second one is, even though there would be a diffusion controlled environment, if you can't maintain the saturation under heat, it tends to crack.

So those were the two reasons I think that we decided bentonite is wonderful for a saturated environment but questionable for an unsaturated environment.

MR. PETERSON: It looks like a conspiracy to talk about the diameter of the drift, but I assume that these temperature limitations were for a given linear loading. Is that right? Or given waste package.

MR. BAILEY: There is a series of design waste packages that we look at, yes.

MR. PETERSON: If you reduce the drift diameter and you reduce the load diameter which is to say you reduce the thermal load in proportion to the square of the drift diameter, then the ratio of thermal load to surface area changes favorably, so all the temperatures go down.

MR. DOERING: We had done some studies in this area. If you don't have the convection going through pushing a lot of air, radiation is the dominant heat transfer mechanism inside the packages, and that's what is really the benefit in the in-drift emplacement. So you do have a large area to radiate to and to remove the heat from the package. If you get smaller packages, that helps you, and you put less heat in the package. So you can do some tradeoffs with that.

The tradeoff we did was with the 5, 12 and 21. We try to keep them with our 18 kW package, and we did some variation on that too. If we move off of that, we would require some blending and some holding time, and I can talk to that a little bit tomorrow also.

MR. BAILEY: Remember what we are trying to accomplish here, as I said very early in my presentation, is we are working on the VA and we are trying to find out what we should be studying about the alternatives. That's where we are going right now and that's what we are doing.

They are good questions, but there are details of how we tweak it a little bit. I don't think I said we ruled anything out and that anything was gone. I think shielding is a little problematic, but we basically haven't thrown anything out and we are finding out what we need to go look at. Your questions are reasonable and what it is that we need to look at. So we are continuing to do that.

DR. NELSON: Any final questions from the Board?

[No response.]

DR. NELSON: I thank you very much for doing double duty, Jack, and thank you as well to Jim. Appreciate those presentations.

We will have a break now for 10 minutes. Reconvene in 10 minutes, back on schedule, I hope.

[Recess.]

DR. ARENDT: The balance of the afternoon will be spent on a session on repository concept of operations. There will be four presentations: Overview of repository operations; subsurface operations, remote operations, performance confirmation facility design.

The concept of operations is extremely important as it relates to cost and safety.

Another factor is the recovery of failed remotely operated equipment is very expensive, particularly in drifts that are 1,200 meters long.

So these are things that the Board is interested in.

Our speakers this afternoon will start with Paul Harrington. Paul is a team leader for the license application team for DOE. He's a mechanical engineer, and he will give us an overview of repository operations.

MR. HARRINGTON: You mentioned the Con-Ops on one of the earlier slides today. We did have a bullet on there for the update of the Con-Ops document to happen in July of next year. So we agree that that is important. I wanted to mention that.

[Slide.]

MR. HARRINGTON: The objectives today. We will talk about the overall repository site, the surface operations area, what goes on at the north portal, and talk through to the handling activities in the waste handling building.

[Slide.]

MR. HARRINGTON: First, an idea of what it is we expect to have come to us. This is representative.

This has loaded weight. We know now that some of the canisters that we will get will be heavier than this. Specifically, the naval canisters are a little bit larger than what we have been using as our design. The navy hasn't closed on their design. They are trying to bring theirs down to be as minimally impactive to us as they can. When that is done, then this design will be readjusted to accommodate that.

A lot of the products that we have sizing already done for bridge cranes, canister handling devices. That is preliminary; it's conceptual. As we close with the navy on the size of their canisters and as we work through with the RSAs, what we may be getting from them, that will have to be adjusted.

We have been putting most of our design work into the major uncertainty areas and waste package and subsurface design, the surface facility. We are developing a concept for the operation. It will support the cost estimate and the viability assessment, but we are not doing a lot of detailed work for that.

[Slide.]

MR. HARRINGTON: The overall MGDS operations area includes the north portal operations area. There are blowups of this later in the presentation. Waste packages will come down the north ramp to be emplaced in the subsurface emplacement drifts with development proceeding out the south ramp.

As Dick said earlier, we will be emplacing through the north ramp. There will be ventilation barriers across the drifts separating the emplacement from the development side with concurrent excavation activity going out the south ramp.

[Slide.]

MR. HARRINGTON: Overall at the north portal waste comes in both in rail cars and trucks through the security station at the portal. This is a truck parking lot, a rail storage yard. This is a carrier preparation building. There is more truck parking. One rail line goes up to where the empty new disposal containers are received.

[Slide.]

MR. HARRINGTON: This is the main building of interest, the waste handling building. The waste treatment building is attached to it. The administration area is adjacent to it with warehouse, shops, admin, et cetera.

We published a rev 1 to the RDD, the repository design description document, a month ago. We talked earlier today about the evolving design. This looks a little bit different than the drawing that is in there. Specifically, the disposal canister receipt facility is now integral to the waste handling building. It had been separate, and this building has been turned 90 degrees. It works a little better for us that way. As you compare the RDD to this, this is an update.

[Slide.]

MR. HARRINGTON: There is a mockup building there. This is obviously post-license application, post-construction. That building will be used for development of whatever subsurface operational or even surface operational activities we may need to do. It's not going to be the location that we do the proof of principle testing that we will identify in the license application.

[Slide.]

MR. HARRINGTON: This is tough to read. I brought a second set that will walk through the activities themselves.

Nomenclature. Carriers are either rail cars or trucks. They will come in. They will have casks on them. The casks may or may not have canisters in them. If there is a canister, it may or may not be disposable.

Once we take the canister, if it is disposable, or the fuel if it's bare, we will put it into a disposal container. A loaded disposal container is considered a waste package. There is a whole series of terminology. I'm not sure that everybody has gotten all of that before.

[Slide.]

MR. HARRINGTON: This is the carrier bay. This is where incoming carriers, both rail and truck, will be received.

I skipped on the outside, and I'll back there just momentarily, because we have to prepare the carriers before coming into the waste handling building.

[Slide.]

MR. HARRINGTON: This is the carrier preparation building. In there there will be a receiving inspection. The load limiters, the impact limiters will be removed, and the personnel barriers will be removed. From there it's ready to come into the waste handling building.

[Slide.]

MR. HARRINGTON: When it gets to the waste handling building -- this happens to show a rail carrier with the impact limiters removed. It goes through a water washdown to remove any road grime. Then it's taken into the carrier bay where it is upended. The washdown is outside at the prep area. It comes into the carrier bay. There is a bridge crane that will take it to one of three wet trains or two dry trains. We call them assembly lines for handling of individual fuel assemblies, or the canister line for handling of disposable canisters.

Disposable canisters. There will be the navy canisters we expect to be disposable for SNF. We may get some disposable commercial canisters if the multipurpose canister concept comes to fruition. And the high level waste canisters will be disposable.

This comes in. The cask gets upended by the bridge crane, lifted out to the trunnions, picked up and moved over and set it on a transfer cart.

[Slide.]

MR. HARRINGTON: For the assembly side of it, if there are individual assemblies to be handled, the transfer cart will go in one of these three doors. At that point it will be brought in through an airlock, set into a preparation area. The cask lid will be loosened. Gas sampling will be taken of internal gases. It will be vented; it will be cooled.

[Slide.]

MR. HARRINGTON: This shows a cask lid being removed. That's only in the event that has a disposable canister, has a dual purpose canister in there. If that is bare fuel in there, then the cask lid is not removed.

The cask is then taken and set into the pool. If there is a DPC in it, then the DPC is removed from the cask. The DPC lid is cut off the DPC and set in there. If there was no DPC, then the cask lid is removed. In either event the fuel is available in an uncanistered cask here or in a DPC with the lid removed there.

[Slide.]

MR. HARRINGTON: Fuel transfer machine or assembly transfer machine will remove the individual fuel assemblies and can put it into storage racks or directly into the transfer canal.

All of this is standard power plant mechanisms. It's exactly the same or virtually the same as we used in the power plants to get fuel from the waste handling building into the fuel handling building and the containment.

It can be stored there, individual assemblies stored under water for blending, for thermal or criticality, or other issues you may have.

[Slide.]

MR. HARRINGTON: When it's time to load it, it will be dropped into this, laid down on the incline, taken up.

[Slide.]

MR. HARRINGTON: There is a transfer machine that will pick it up here, take it through a transfer port into a drying station. It's a vacuum drying station. It will dry it. It's a sealed port to minimize contamination transfer.

Once it has dried it will be picked up, moved over and set into a disposal container through another transfer port for radiological contamination minimization.

[Slide.]

MR. HARRINGTON: When the canister is full, then it will be temporarily lidded and rolled on a cart out through an airlock to this decon cell. The remaining decontamination will be done; it will be backfilled with nitrogen and taken out to the welding area.

We will treat that in a moment.

[Slide.]

MR. HARRINGTON: This was the individual assemblies getting into disposal containers. If we receive a canister, it goes up the other line, the dry line.

[Slide.]

MR. HARRINGTON: Before I jump to that, let me show on the plan view these things. This was the preparation pit. It was moved into the pool here. The assemblies were taken out, set into the racks there, run through the incline plane, and moved into the disposal containers at that point. The disposal container is then ready to be moved out through that door into the welding area, the sealing area.

If you have canisters instead, it will go up these two lines. They're dry. One of the issues we've had is, is it better to do wet or dry handling? Both systems have advantages. We've chosen the dry handling for canisters to minimize radwaste generation. We have chosen the wet handling system for handling individual fuel assemblies. It gives us a lot more operational flexibility.

[Slide.]

MR. HARRINGTON: For canisters, the casks will come in, go through the same preparation area. This is a manipulator to remotely de-tension the lid, do the same venting, gas sampling. There is a decon station here for on the way back out. It goes inside and the lid is removed. The canisters are individually taken out.

If it is a large spent fuel canister, an MPC, a navy canister, it will be set directly into a disposal container. If they are the smaller canisters for DOE spent fuel that would come canisterized or high level waste, there are some storage racks that they may be set into. It's operational flexibility.

Some of the DOE SNF is commercial in origin and it will be handled as other commercial fuel. EM is expecting to send us some uncanisterized DOE SNF which has commercial origins. But the majority of it will come in canisters like this.

Once it gets inserted into this disposal container, it's lidded and moved out to the disposal container handling system.

[Slide.]

MR. HARRINGTON: Now we have taken canisters or loaded disposal containers both through the dry system and through the wet system and have them here staged at these four carts ready for welding. The transfer cart has brought it out. Bridge crane will pick it up, can stage it or it can sent it directly to the welding station.

[Slide.]

MR. HARRINGTON: This shows having the canister turn and the welding head stationary. That's another one of our open issues. This is a system that we believe can work. The last repository consulting board meeting we had they had not yet come to agreement within themselves. One factor says turning the cask is the better move; another factor says having a rotating welding head is the better move.

This is our approach at this point. This gives us some more flexibility in that the welding gantry can be readily removed for maintenance.

[Slide.]

MR. HARRINGTON: The inner lid is what gets installed in here. This will be brought out. The inner lid will be welded. It will be NDE'd, backfilled with helium. Then the outer lid, the canister allowance material will be installed, welded, NDE'd. At that point it's picked up and brought over.

[Slide.]

MR. HARRINGTON: There are some staging areas for completed disposal containers, which are now effectively waste packages. They're loaded, they're sealed, they're ready to go.

[Slide.]

MR. HARRINGTON: When they are ready to be loaded underground, they are brought into the tilting station, hooked up to the trunnions, lowered down onto transfer carts, moved out into the decon area, picked up through a handling device with a similar configuration to the trolley underground, engaging in the skirts, loaded onto a rail car and moved into the transporter. At that point it's ready to go underground.

[Slide.]

MR. HARRINGTON: Also on this is a change from the one that is in the RDD. It's an evolution. We now show emergency generator and HVAC areas. They weren't in the RDD. It's an evolution.

[Slide.]

MR. HARRINGTON: There is more detail in the kind of cold and hot support cells that you need. This has the waste treatment building adjacent to it. It will be fairly standard radwaste handling processes.

[Slide.]

MR. HARRINGTON: There are sections through the building. This is through the assembly transfer line, the bare fuel line. This is to through the canister line. As you saw before, the carrier bay, the cask preparation pit. The cask gets lowered into the pool. Assemblies are individually removed and set into storage racks.

[Slide.]

MR. HARRINGTON: This is the inclined plane that takes it up where they are put into the dryer and then into the disposal canister which is taken out into the disposal canister welding area.

[Slide.]

MR. HARRINGTON: This one is a little more straightforward. It doesn't have the equipment for bare fuel handling. You don't need it.

Questions?

DR. ARENDT: Thank you. Are there questions from the Board?

Dan.

DR. BULLEN: You are going to take all the spent fuel assemblies and put them back into water. Do you have any concern about their integrity having been in dry cask storage for maybe 20 or 30 years? I guess the question I raise is the issue with respect to degradation within a dry cask storage environment which I don't know how much we know about.

MR. HARRINGTON: Certainly degradation during in-storage is going to be an issue.

Jack, have you or your folks looked very closely that yet?

MR. BAILEY: Specifically, we look at the thermal question and we cool the fuel down slowly to avoid the thermal question. The degradation question has been looked at. I don't know the specifics of it. It has to do with the ongoing question of clad integrity. So it deserves a little bit more look.

MR. HARRINGTON: For DOE SNF we know that a lot of that, the in-reactor fuel particularly, we will not handle that there. That will come canistered.

DR. BULLEN: The concern would be creep rupture, hydride reorientation, those kind of things.

MR. HARRINGTON: Yes.

DR. ARENDT: Other questions?

[No response.]

DR. ARENDT: This is fairly straightforward technology and there is nothing really new here, as I see it, except maybe some details. I believe that's it then. Thank you very much.

Our next speaker will be Daniel McKenzie. Daniel is manager of the subsurface repository design for the M&O. His topic is repository concept of operations, subsurface operational area.

MR. McKENZIE: Good afternoon. I'm real glad to be back up here and talk to the Board again. I think the last time I talked to the Board was two and a half years ago or so. I think it was Mr. Arendt's very first meeting.

Two and a half years is a long time, but I'm back and I want to tell you a little bit about the subsurface concept of operations. I really kept this briefing very simple. It's just a few charts.

Essentially all I'm going to do is describe how the waste packages get from that waste handling building.

The last chart that Paul had showed the package going into a transporter, and I'm going to take it from that point down into the underground until the package is set on the pedestals and its final emplacement place. Then there should be plenty of time for questions. This shouldn't run too long.

[Slide.]

MR. McKENZIE: The transporter is moved underground. The transporter is not self-propelled. It is pulled and pushed by two 45 ton locomotives. You really can make case that only need one, but we put one on either end as an extra measure of safety.

The transporter provides a certain amount of shielding to allow manned access around the transporter when it's required. It's not usually required. There is an operator in the locomotive, but he's a good distance away from the transporter. So you don't need to have this 2.5 MR per hour dose rate.

The dose rate at the surface of the transporter with the design basis package -- the design basis fuel is very hot, very young high burnup fuel. The dose rate is about 40 millirem per hour on the surface of the transporter. For average fuel it's about 10.

The shielding in the transporter. For gamma shielding you have carbon steel and for neutron shielding there is borated polyethylene. Altogether it's about 10.5 inches thick with the stainless steel layer on the inside and outside.

The empty weight, as it says, is 164 metric tonnes. A pretty good load, a pretty good size rail car. The heaviest package in it, 233 tonnes. So it's pretty easy to see how we arrived at rail haulage for our waste transfer and movement, because you've got a pretty heavy load to move around. It's also why we laid the repository out very flat with various shallow grades.

[Slide.]

MR. McKENZIE: The arrows is the direction of waste travel. Everything comes down the north ramp, and if it's going to be emplaced in the eastern half of the block, it comes down this way and it's emplaced from this main. If it's going to be emplaced in the west side of the block, it comes down around here and it's emplaced from the west side.

So emplacement proceeds drift-wise from north to south, but within a single drift, the first package from the west is emplaced right there and you work your way back out. I'll talk about this again in a minute.

We talked about the carryover capability, but that's not the VA concept. The concept is emplace the packages sequentially from the furthest one in first all the way out to the door. To do it the other way involves more complexity in terms of failure modes and how to recover from them, just like Dr. Bullen was talking about earlier.

[Slide.]

MR. McKENZIE: This is a 3D CAD, one of our engineering drawings that we just cut a slice out of. We have a nice 3D CAD system where you can get these views like this and send them to another routine and color the surface so they look nice. It is to scale, essentially.

This is the transporter. This is the 233 ton gross weight vehicle, two 45 dc trolley locomotives. They are the 750 volt dc trolley system that powers the transportation system, 1,500 kW rectifiers and all that good stuff.

Peak starting load is based on two locomotives starting under full load and also a gantry operating in that same electrical area so that it also is under its full start-up load. That's what the rectifiers are based on.

[Slide.]

MR. McKENZIE: The locomotives move the transporter from the surface. They come in the north portal, down this ramp. It's 2.15 percent ramp. Most of you have probably been in the tunnel. It's very flat. When you are standing there, you kind have to look both ways to see which way is downhill. That's the kind of grades you want for rail haulage.

This is about the steepest grade that you have to move the package on, 2.15. It comes down around the curve. If it's going on this side, it actually turns and goes back uphill from that point. That's the lowest point, 1.35 percent. So it's still very flat.

The transporter will be moved either to the east side or the west side. I think the rest of my pictures show a view of it on the west side, and we'll look at that in a minute.

[Slide.]

MR. McKENZIE: The shielding transportation portion lasts as long as the package is in the main.

[Slide.]

MR. McKENZIE: This picture kind of assumes that we are in that area somewhere and we are kind of looking at it from that angle. We are looking to the northeast.

[Slide.]

MR. McKENZIE: This is kind of a compressed view. These are the bulkheads that separate the emplacement system from the development system. In real operations you wouldn't be this close. There would be probably half a dozen drifts between you and the bulkheads, but I just kind of squashed it all together so I could get it all in one picture and get some decent detail. So these are bulkheads.

This is the development side. Normally people or equipment, neither one, pass through those bulkheads. They are only there and there are doors in them for people to move only in emergencies. So there is not a lot of traffic passing through the bulkheads from one side to the other.

[Slide.]

MR. McKENZIE: Since we have a locomotive on each end, we have to drop one of them. He uncouples. The other locomotive just pushes and backs the transporter in up close to the doors. This shows it already there and doors all open. There is a transaction that happens.

The transporter moves to within four or five meters of the door. At that point the operator leaves. The operator can back the locomotive in there, but then he leaves after that. He just walks away from the area. The rest of it is done remotely from the surface in a control station. It's not automatic. It doesn't happen by itself, but there is a guy on the surface pulling the switches.

The doors are opened on the transporter. The transporter has doors that open 270 degrees, all the way around so that the doors are actually against the sides of the transporter. These are the blue doors here, the doors to the drift. The drift door is open, the transporter is backed up to a loading dock, and it matches up to the loading dock. That's the end of the transportation phase.

There is a car inside of the transporter. You saw it in the surface discussion that Paul gave. The package was set on a little car and that car is drawn into the transporter. It's an integral part of the transport unit. It has what is called a rigid chain concept that allows the machine to push the car out of itself and then pull it back in.

The package is deployed into the position you see there on the loading dock. It's still sitting on the car that it was pushed out of the transporter on.

[Slide.]

MR. McKENZIE: The last part of the emplacement process is this gantry. This is sort of a notional picture. I will show you a little bit better although not quite as pretty a picture of it here in a minute.

This is the gantry. It moves in. It's dc powered also. It moves in over the package. It essentially goes over and straddles it. It lifts it by the ends, just like the crane you saw on the surface. The package is countersunk on the ends; it has flanges. It reaches over and picks it up and trams into the drift to the point where it is to emplace that package, and it sets it down.

The gantry is remotely operated. There was a concern because of the radiation environment. You have to be able to recover it. We have spent most of our time trying to make the gantry very, very bullet proof, to have a lot of redundancy and to be a very simple machine. We don't want it to have to do too much.

[Slide.]

MR. McKENZIE: This is just another picture zoomed in a little bit more. You can see the package sitting on the cart and the gantry is poised and ready to come over and engage the package and pick it up.

[Slide.]

MR. McKENZIE: The key thing here is the gantry doesn't have to do too much. It has to engage packages, it has to disengage them, it has to raise them, it has to lower them, it has to motivate itself with dc power along a drift. Its trip is a maximum of 600 meters one way. It doesn't go 1,200 meters. It only has to go from the edge of the block to the center and back. That's the longest trip that it makes. So we've tried to keep its mission pretty simple so that we can make the machine simple.

[Slide.]

MR. McKENZIE: All this machine does is engage and disengage, raise and lower and move. It's has four wheel units. It's driven on all four corners but only two of those wheel units have to run in order to get it back out. That is one measure of redundancy. It has multiple controllers; it has multiple communication systems.

These boxes on the end are fairly thick. They are shielded boxes for electronic components that don't get along well with radiation. The printed circuits and what not are shielded inside there so that we don't have to worry about them failing from the radiation.

The dose is like 40 REM per hour or something with a design basis package. It's not a super high high radiation field, but it's high enough that it can affect the electronics.

[Slide.]

MR. McKENZIE: I'd like to have a chart here to show you my go get it machine, because we always worry about if it breaks down and it just won't talk to you and you can't talk to it and it just won't come out, and how are you going to get it out of there.

The way we are going to do it is just to pull it out. We are just showing tow lugs down on the tows of the wheel units. We'll have a machine that is just a simple heavy locomotive type of machine that can go in, grab onto those lugs and drag it out of there. That's kind of the fallback position. If all of my redundant controls don't work and my redundant wheel units don't work and all that sort of thing, we'll go in and pull it out that way.

Actually we have measures beyond that if we have to get into very abnormal conditions, roof falls and that sort of thing. We have measures described in some analyses that are for really severe cases, but we don't want to get into those. They're not a part of the normal operations.

[Slide.]

MR. McKENZIE: This is the picture I was talking about. It demonstrates that there is not a whole lot of wasted space in that drift right now. It's a 5.5 meter drift with a 200 millimeter liner, which gives you 5.1 clear. We told the gantry designers that the last 100 millimeters they can't have. Their machinery -- nothing can protrude into that 100 millimeters. They actually did pretty good. There aren't any places that protrude within about 180 millimeters of the liner. So they got it in there.

[Slide.]

MR. McKENZIE: This is a 2 meter diameter waste package, and that's another one. If you want to maintain the ability to carry one over the other, you can see that the drift is just not going to get a whole lot smaller; it's reasonably tight in there right now. If we decided that we didn't need to maintain the ability to carry over, it doesn't get as small as you think. It gets down to still in the 5 range, 5.2. The gantry still has to have a fair amount of mass and it has to be able to lift the packages.

I think I have a picture that might have shown a shadow shield. That's a concept that we have incorporated in VA.

[Slide.]

MR. McKENZIE: This is really a high tech deal here. That's a big block of concrete. We can set that in there. We call it a shadow shield. It just precludes a direct shine from coming out of the drift and it lowers the dose quite a bit at the door. If you want the shadow shield to be in there all the time while you are emplacing that drift, you always have to be able to carry the packages over it. So you have to raise the package kind of high.

That's a tradeoff. You decide whether you want that dose attenuation all the time or can you afford to have a higher dose there until that drift is full. Then you could set that shield in there at the end of that. When that drift is full, then you could put the shield in. So we got a little choice to make there. They don't cost much and they're a real good measure to keep the dose down in the mains.

[Slide.]

MR. McKENZIE: I mentioned that one shows carry over. Carry over is really not in the concept. It's just something that has been expressed as a potentially good thing, so we shouldn't preclude it. It's kind of like backfill. So we have maintained the ability to carry one over the other, but we haven't looked into what the differences might be in licensing an emplacement system that this ability to carry over versus one that didn't, that was never was going to go beyond packages.

[Slide.]

MR. McKENZIE: This one shows what it looks like ultimately. The packages are just sitting in a drift. These are carbon steel pedestals. I notice that there are different spacings here. That's a true rendering. The packages are not all created equal, so they are not all going to be spaced equal. Some of them will be very close together, some of them there will be a fair space between them.

This is what it looks like for quite a long time until the liner starts to degrade.

[Slide.]

MR. McKENZIE: This is called a remote inspection gantry. This is the only piece of machinery that we have in our arsenal that is conceived to go into the hot environment, up to 200 C type environment. This is a performance confirmation tool. I think Bill is going to address it. It's one of our data acquisition methods for performance confirmation. It just thought I would put it on here and show how it fit into the geometry of the drift.

[Slide.]

MR. McKENZIE: The Board asked for a discussion of failure mode. I think this springs from the fact that if it breaks down in there, how are you are going to get it out? That's a valid concern.

The formal evaluation FMEA, failure modes and effects analyses, is going to be done prior to LA and the results fed back into the design.

From the beginning, the design for this concept has really focused on the elimination of these single point failures, the things that really can hang you, that can get something stuck there and you have a hard time getting it out. These are just a few of the things.

Multiple control unit. It's programmable logic controllers in a network where there are multiple PLCs. The failure of any one PLC is not going to torpedo the operation; it can work around it.

Two separate communications systems. It will be direct radio communication and one of two other concepts, either leaky feeder coax cable or slotted microwave. Either one of those two concepts. So you have two totally separate and different concepts for communicating with the machine.

It's a dc powered system, and the power feeds from both ends. You have a dc network that goes all the way around the block and you have feeds from both sides. The pickup bar for the dc power is continuous from the east all the way to the west. So you get power feeds from either side. So it takes two short circuits in order to interrupt power to the gantry.

If you noticed on the gantry picture, there are two power pickups, one close to either end of the machine, so that it has two different connections to the bus bar so it can pick up power.

Those are the kind of things that we are trying to design into it to make it as bulletproof as we can.

Continuing strongly this year we are looking into NRC guidelines, trying to use all the guidance that is available to us from the NRC in the way of crane design and maintenance and that sort of thing. We are going to try to incorporate all the stuff that the NRC is already used to seeing in crane development so they'll be comfortable with it when we present it.

We talked to some vendors that supply cranes to the nuclear industry so that we can start thinking along those lines.

[Slide.]

MR. McKENZIE: You can't go out and buy a waste emplacement machine. Nobody has ever made one before. We are trying to build it as much as we can out of components that are available. A good example are those wheel units, those wheel bogies. Those drive units are the same thing you see on various kinds of bridge cranes. Although you can't buy an emplacement gantry, you can buy a lot of the parts as components that exist. That is fairly important from a reliability standpoint.

I already mentioned that PLCs are going to be used pretty heavily. They are simple; they run on a simple logic; and they are going to be the basis for the control system.

The formal failure mode evaluation is really an LA activity.

I think that's all I got.

DR. ARENDT: Thank you.

Are there any questions from the Board?

Jerry.

CHAIRMAN COHON: Why would you use people at all underground in waste emplacement?

MR. McKENZIE: That's a good question. Essentially the only guy is the fellow that runs the locomotive. You only need one because it's a master/slave situation where one locomotive is synchronized with the other one.

It's almost a perception sort of thing. People are going to worry if we just kind of turn that waste package loose at the surface and say good luck. I think it's almost a perception thing. If we could get away from it, it's not a lot of money, but the machinery would look much the same. The locomotive is remotely operated. It can be remotely operated or manually operated.

CHAIRMAN COHON: Getting the waste to the drift is the simplest part. It should be the easiest thing to do without a person.

MR. McKENZIE: It would be reasonably simple to do. There are ramps to be negotiated, curves and switches in the mains. The emplacement drifts are dead straight and no curves, no switches, no anything. It is a pretty simple transfer. You're right. We tried to make it that way.

CHAIRMAN COHON: We've got robotic vehicles that can drive highways.

What happens to the gantries after the waste is emplaced?

MR. McKENZIE: I would think you would store them. They are, number one, the primary retrieval mechanism. If everything is normal and retrieval is mandated because either your long-term performance is projected to not be what it's supposed to be or you need the fuel back for recovery of resource or whatever, you would retrieve in the reverse of the emplacement process. You would use the same machinery if it was still available.

If has been sitting there for 50 years, it may not be very serviceable. You'd probably exercise them and keep them up, at least one or two of them. You're going to have half a dozen of them. They're just there to help you move packages if you need to move packages for one reason or another.

CHAIRMAN COHON: Is there some provision for substitution of gantries that fail for one reason or another?

MR. McKENZIE: As with almost any machine that has got more than on part, you keep a spare one around. We'd probably have six to run four, or something like that.

CHAIRMAN COHON: Have you gotten to the point yet where you can estimate how long it would take to move a package from the surface to emplacement?

MR. McKENZIE: In general terms, yes. Most of it is transport time. We don't let it go very fast. It goes like 8 kilometers an hour, or 5 miles an hour. That transport time can take upwards of an hour. The total cycle time is less than 4 hours. It's maybe 3 hours or something like that. It depends if you are going there or there.

CHAIRMAN COHON: Thank you.

DR. ARENDT: Dan.

DR. BULLEN: A quick and easy one. It looks like you've essentially identified the limit of waste package spacing. You've got to have the ability to get in there and grip it and it looks like you've got about a meter or so on the ends. When we talk about line loading of waste packages, we are basically limited by getting in there and grabbing the ends of the containers.

MR. McKENZIE: If you use this concept, yes. If we want to stay with this gantry concept, a meter is about as close as it's going to get. If we want to go line load, we could probably come up with a way of engaging it from the side or something. We haven't thought a whole lot about it, to be honest with you, but there has got to be more than one way to pick up a can.

DR. BULLEN: If you did line load, then maybe the waste package designers would look at a different way to pick up the can as opposed to using those lips on the end?

MR. McKENZIE: Yes. You probably wouldn't want to engage it from the end if you were going to try to line load and really put them close together, because you've got to have room to disengage too. I'd probably be looking at some sort of a side lift mechanism. Maybe you could put lugs on it or something.

DR. BULLEN: Thank you.

DR. ARENDT: Paul.

MR. CRAIG: I'd like to hear a little more discussion about the kinds of accident failures that you might think about. I presume you have a list of events from which you might have to recover. I'm thinking of events such as unlikely things, a rock fall where the top of the tunnel caves in, or an earthquake where you get an offset in the tracks. How do you go about recovering from events of that sort?

MR. McKENZIE: I knew somebody was going to ask that. We have done some analyses for fairly extreme cases. It was done as a retrieval analysis, but it applies to any kind of an off-normal type of thing.

Let's say you have roof fall in a drift and it's tight and it's on the packages. That is obviously an off-normal situation that you are not going to continue to operate in, at least in my mind. I can't say I know how this place is going to operate exactly, but if I was the NRC, I would probably make us stop for a while if I had a big fall in an emplacement drift and clean it up.

Assuming that the concept was going to be we are going to go in and clean that up, our concept for that would be to in as normal a manner as possible recover the packages that are between the door and the fall with the gantry. Just take them out one at a time starting with the closest one and working my way to the fall. After that you have to set up to do a very abnormal process. You might bring in fill with normal type mining equipment. I happen to have 10 million tons of crushed tuff sitting out in a pile. So I've got plenty of fill.

I could bring in fill and build a roadbed so I don't have to worry about running on the rails. They're not going to be much use to me because of the fall up in that area. I'd build a roadbed and I can used rubber tired or crawler vehicles to get in there and break up the fall and move it.

Again, this stuff has got to be remotely operated from a distance. It doesn't necessarily have to be run from the surface, but it has to be run from a position where the operator is safe.

We have sort of notional pictures of a machine that has multiple uses. It has an arm on it and it can be used to grapple, connect a cable onto a package flange, or it can be used to break up rocks with a hydraulic hammer. Or you can put a backhoe bucket on it and scrape rocks away. It's a fairly primitive process, as you can imagine. It's not going to be elegant or pretty. But we have a way lined out that we think we can do it, and it's really pretty central to the whole concept.

DR. ARENDT: Alberto.

DR. SAGUES: This is related to the same thing. You are going to have a couple hundred miles of rail?

MR. McKENZIE: One hundred fifty-seven kilometers of drifting, right.

DR. SAGUES: That's going to have to be available for what, about 100 years?

MR. McKENZIE: Right.

DR. SAGUES: Any idea what the statistics are of failures in a mining type environment and the like? Would you expect you are going to get a failure, or does it look like a very remote event?

MR. McKENZIE: A failure of the rail system?

DR. SAGUES: Right.

MR. McKENZIE: I suppose you could. If we got a bad enough failure that the gantry system is not feasible, then we are going to have to go to the brute force, put in fill, and pull them out that way. Remember, the traffic on this rail system is going to be very, very low when compared to any kind of rail system you've ever seen. There's only 10,213 packages to get emplaced over the course of 24 years. So there are not going to be any wear problems. Nothing is going to wear out. It will get old, but it won't wear out.

Again, the rail or the bus bar could also be a failure point. Those are both things that we have to be able to recover from. I think we have a couple of things in our pocket that we can use to deal with those situations.

DR. ARENDT: Questions from the staff?

Bill.

MR. BARNARD: Dan, I've got a couple questions for you and then a couple for Paul.

On an annual basis, how much spent fuel are you estimating that you can emplace?

MR. McKENZIE: It gets up to 3,000 metric tons a year through the fifth or the sixth year. It goes 300, 600, 1,200, 1,800, and then I think it goes up to 3,000 MTU. The peak year for waste packages total is 524. That's the highest single peak year with the current waste stream, and that includes the DHLW, DOE spent fuel packages. So you are looking at just commercial fuel probably 400 packages or something a year.

MR. BARNARD: What is the estimated lifetime of your carbon steel pedestals?

MR. McKENZIE: I hope it's at least 100 years. I'm kind of a preclosure guy, but Jack always beats me when I say that. The pedestals are part of the engineered barrier system. They are actually being designed by the waste package design group. That's Tom Doering, if he is out there somewhere. But I don't think they are considered to be particularly long lived. They are just carbon steel and they're not real thick. I don't think they are going to have the longevity of the waste package, for example.

MR. BARNARD: A couple questions for Paul. What is the annual handling capacity of your waste handling facility?

MR. HARRINGTON: Peak year it's 700 casks, and we expect to ship out in a peak year 400 empty DPCs.

MR. BARNARD: So it's compatible with the 3,000 metric tons a year that you are emplacing in the repository?

MR. HARRINGTON: Yes. The waste handling building was sized with that same 3,000.

MR. BARNARD: How much spent fuel do you assume is in lag storage?

MR. HARRINGTON: We have several different areas, as we showed on the slides there. It varies in the different storage areas between about two and a half weeks and six weeks.

[Slide.]

MR. BARNARD: Do you assume that you are going to have 10,000 or 20,000 metric tons of spent fuel in lag storage?

MR. HARRINGTON: No, no.

MR. McKENZIE: No, no. It would be nice.

MR. HARRINGTON: If you add up two and a half weeks worth in casks out on the rails or trucks, another six weeks in pools, another three weeks in dry canisters, and another two weeks in loaded disposal containers, it's 13-1/2 weeks out of 3,000 MTU per year.

MR. BARNARD: So it's a fairly continuous operation of unloading, loading, and emplacement?

MR. HARRINGTON: Yes. We expect to have something less than half of the storage capacity full at a given moment just to have some surge capacity.

MR. BARNARD: Good. Thank you.

DR. ARENDT: Questions from the consultants?

MR. KUHN: Why do you put the containers on these pedestals and not simply on the floor?

MR. McKENZIE: I guess it's to keep them up in the air and out of the water. We always talk about there's not much water here. I guess I'm not the right guy to answer it. We could set it in a cradle or dead on the floor.

Tom.

MR. DOERING: We've looked at different methods of emplacing those things on the floor at one time and then just on the concrete piers, and we looked at the supports that we are dealing with. What we looked at for VA was leaving it on the supports at this time for a couple reasons. One, if there is some moisture down there, it keeps it off the moisture, and also in the early time frame, when we are looking at early fuels, we would cooling or radiation out of that, so there is no hot spot on it.

For VA design this is where we want to be, and the recent reevaluation how the system all fits together a little bit later. That's where we are right now. There is clearly some more reevaluation to be done, but it is a very straightforward way of doing it. The design is such that it is tolerant to a lot of environments there.

DR. ARENDT: Thank you very much.

Our next speaker, Paul Harrington comes back and will discuss subsurface remote operations.

[Slide.]

MR. HARRINGTON: There is a need for remote handling capability in the repository as we have it designed because of radiation fields, 40 r per hour contact on the waste package surface.

Elevated temperatures during emplacement period, we expect a max of 50 degree centigrade. That's basically a hot summer day in Las Vegas.

After emplacement in a drift is completed and the ventilation control doors are closed, then it will go up. So during the performance confirmation phase, the post-emplacement phase, we expect to have on the order of 200 degrees. The environment that performance confirmation needs to function in will be that.

If we have to reverse the emplacement process, our expectation would be to open up the drifts, ventilate through the drifts, bring the temperature back down and be back in this 50 degree environment.

There are large and heavy payloads. I talked a little bit ago about what those expected canister weights are. The heaviest one is still a TBD, but it's something on the order of slightly greater than 75 tons in confined areas.

There are several design assumptions that affect us.

The first one is no entry is planned into the drifts because of the thermal and radiological environment.

Second, we do need to design for retrievability. Dan talked a few moments ago about some concepts for that retrievability.

One comment that I would want to make. There was a question about the emplacement gantries. The gantries are to move from one drift to another. They will do emplacement in a drift and then removed and used in subsequent drifts, and they can be maintained. So it's not something that you put in and can't ever get out again.

Performance confirmation for remote inspection capability. That will be in a 200 degree C environment. We have to design for that.

It will be on pedestals, as Dan talked to a moment ago.

[Slide.]

MR. HARRINGTON: We have been looking a lot at what is available in industry around the world. Obviously no one has ever done something quite like what we are doing, but there are a lot of precedents out there for pieces and components that we can use.

In the mining industry, there are remotely controlled locomotives; load-haul-dump. For those that haven't seen them, it's a short front-end loader; subsurface control and communication.

Rail transit. There are a number of different rail transit systems around the country that are not manually operated. They are either remotely operated with a driver available but not in control. Some of them don't even have drivers on them.

In the nuclear world, the ASME Code section 11 requires in-service inspection of nuclear components on a 10 year basis. A lot of equipment has been developed for high radiation areas, remote handling, to go in and do that in-service inspection, primarily UTs. There are some other requirements too.

[Slide.]

MR. HARRINGTON: In the manufacturing world there is a lot of equipment out there. Dr. Cohon alluded to some earlier: remotely controlled vehicles or automatically guided vehicles.

In aerospace, one of the lead design engineers on this project has come from JPL, working on the Mars, has a lot of experience with remote handling, remote control equipment.

We are taking advantage of the institutional research that has been done elsewhere: DOD, NASA, and others.

[Slide.]

MR. HARRINGTON: The control scheme includes a surface operations control center connected via data links, communication links to both stationary and mobile underground. The stationary can be hard wired. For the mobile we have to have something that will allow communications, control of those mobile systems.

For that we have chosen the distributed antenna system and either a leaky feeder or slotted microwave.

I wasn't sure what a slotted microwave was. Maybe everybody else is. I found that it uses a waveguide with a slot in it with an antenna or the antenna is mounted on the mobile equipment and the microwave is shunted down the waveguide and picked up by the traveling equipment.

That will be used for both transport locomotives, for the emplacement gantry, for the remote inspection systems. This is representative of the performance confirmation inspection device. And, as necessary, for remotely operated retrieval equipment.

[Slide.]

MR. HARRINGTON: This is a load-haul-dump; this is a multipurpose vehicle. There are several other concepts for retrieval equipment, including devices that can grab on to the skirt of a package and drag it onto a ramp and then truck it out.

[Slide.]

MR. HARRINGTON: I brought several representative product brochures. This one uses leaky feeder, which is a coax cable with a perforated jacket so it has a local RF field for both sending and receiving signals. It's apparently used widely in the mining industry and some other applications and can be used in ours.

This particular one, Multivision, uses it to control cameras. They have other adaptations of that for actual control of the mining devices, load-haul-dumps, trains, et cetera.

[Slide.]

MR. HARRINGTON: In the nuclear world there is a pretty broad market for remotely controlled cranes, heavy lifting equipment. This is representative of one that handles drums. It's automated. You can punch in the location of a drum and it will remove 21 drums to get to that drum. It's got a control console on the back. This will traverse into the radiologically controlled areas and do it's work independently. The point of this is you don't have to have manual local direct control; it can be remote.

[Slide.]

MR. HARRINGTON: This is a transit system in

Vancouver. There are corporate personnel on the trains, but they don't run them. They are there to take tickets and make sure if there are problems to resolve them, but it's remotely controlled through a central control unit.

One of the interesting things I found was normal railroad technology has fixed blocks. There is a certain length of track that is controlled from a local area as a block. This system uses a moving block; the block travels with each of the trains. These trains travel up to 30 seconds apart. They handle 40 million passengers a year, everyone a potential litigant.

[Laughter.]

MR. HARRINGTON: So they have come up with a system that works, that has worked well for them. They haven't had troubles with it. It requires very accurate measurements. They use a three-computer system where you have to have two agree on any safety-related action. That was their term. I hadn't heard safety-related used outside of the nuclear business.

[Slide.]

MR. HARRINGTON: This is a manipulator that was developed by one of the M&O teammates for use in ISI work, in-service inspection work, in the nuclear world.

This particular one is interesting in that it has most of its electronic controls mounted coincident with the unit. It's a little tough to see the picture. It's not a very large unit, but they are designed to be mounted down in the pool. They have to go into the reactor vessel to do ultrasonic testing of the welds, of the vessels, steam generators, et cetera.

This one is able to package its electronics coincident with the equipment in a high radiation environment and a wet environment. There is a lot of work done in the field today.

DR. ARENDT: Any questions from the Board? Jerry.

CHAIRMAN COHON: Is the environment in emplacement drift expected to be comparably hostile to environments encountered now in nuclear power plants, for example? In vessels, for example?

MR. HARRINGTON: Rad fields in a de-fueled reactor when you have residual contamination, you've got activation -- I don't know the answer to your question directly. Does anyone in the M&O.

MR. BARRETT: It's about the same.

CHAIRMAN COHON: So the experience in those environments should be applicable to emplacement drift environments.

MR. HARRINGTON: Yes.

CHAIRMAN COHON: Thanks.

DR. ARENDT: Other questions?

[No response.]

DR. ARENDT: Thank you very much.

MR. HARRINGTON: Thank you.

DR. ARENDT: Our next speaker is William Boyle, performance confirmation team lead for the assistant manager for licensing.

[Slide.]

MR. BOYLE: Thank you for the opportunity. I'm going to talk about the subsurface performance confirmation facility design. This is at a request of the Board or your staff to have this presentation. Richard Wagner gave a presentation in Las Vegas at your last meeting that did not go into the details of the design.

[Slide.]

MR. BOYLE: The next two pages, 2 and 3 in the handout, are just quotes from 10 CFR 60 as to what's the purpose of performance confirmation. You can read those words yourself and I'll try and summarizes them.

Performance confirmation as defined by Part 60 relates to the postclosure performance. Although measurements will be made for operational concerns, industrial hygiene concerns, they are not part of the performance confirmation program. Only postclosure performance.

[Slide.]

MR. BOYLE: There are two main goals of performance confirmation. One is to confirm that what we thought was there, what we designed to really is there. The other main purpose is once the waste is emplaced, are the natural system and the engineered systems performing like people thought they would.

[Slide.]

MR. BOYLE: The summary of the performance confirmation strategy is to use multiple data acquisition methods to get an overall data set to confirm or revise licensing assumptions.

The reason multiple data acquisition methods are used, and you will see which which ones will be used subsurface, is that no one method in and of itself is sufficient. So multiple methods are needed, which provides some flexibility and some redundancy.

[Slide.]

MR. BOYLE: On the agenda, also requested was a discussion of what data would be gathered. This is from subsurface only. For example, what is not shown here is precipitation. We'll get that from surface measurements, not from the subsurface.

These data needs that are more towards the top of the list are those that are more related to did we find what we thought was there; those more towards the bottom of the list deal with is the system responding as we thought it would respond.

[Slide.]

MR. BOYLE: This is back to the data acquisition methods:

We will have sampling during construction.

Mapping during construction.

Alcove-based testing in non-emplacement areas.

Borehole instruments.

Ventilation monitoring in the ventilation drifts to monitor the ventilation there.

Remote data acquisition from within emplacement drifts. That was brought up by Dan McKenzie with the little device he had pointed out and it was also shown on one of Paul Harrington's slides in the second talk.

There is also the potential of recovery of waste packages for testing.

[Slide.]

MR. BOYLE: This is just an example going into more detail for design implementation of the performance confirmation. This is from one of the observation drifts.

We would have borehole instruments going into the altered zone to make measurements of temperature, rock stress and strain from displacements, groundwater chemistry, moisture content, water vapor content and humidity.

This last point gets at Dr. Sagues' question about the modeling where the water replaces all the other gases. There will be measurements made.

[Slide.]

MR. BOYLE: Also on the agenda was to be a discussion of options considered. This is what we have now. This was one of the options. Ignoring the details in the corners, you've seen variations of this shown throughout the day. This a plan view with the many emplacement drifts, the five performance confirmation drifts.

[Slide.]

MR. BOYLE: As Dick Snell showed earlier in the day, this is essentially on three levels with the emplacement drifts in the middle. The exhaust main is below the emplacement drifts, and the performance confirmation drifts are above.

[Slide.]

MR. BOYLE: There are actually two cross sections and a plan view on this. So I'll block it off as I go.

This is a vertical cross section. This is the existing ESF excavation today. Paralleling it approximately is the exhaust main below the emplacement drifts which run from the existing main to the main to be excavated, and above them at another level parallel to the emplacement drifts would be an observation drift with these drilling alcoves excavated off the observation drift.

[Slide.]

MR. BOYLE: Here is another vertical cross section rotated 90 degrees. Here's the exhaust main. The emplacement drifts and the observation drift are now running in and out of the plane of the screen.

These are typical boreholes to show that one observation drift in this configuration covers six emplacement drifts. As part of the strategy of this concept for performance confirmation in some areas we will get a distribution -- in ever drift we will get some measurements and in other areas we will get much more information for only some of the drifts. So it's a mixture of concentrated measurements in certain areas and distributed measurements everywhere.

With this layout, with five performance confirmation drifts which have access to six emplacement drifts we can have boreholes for some 30 of the emplacement drifts and there are some 100-odd. So we would monitor 30 of them this way.

At the bottom of the figure is a plan view, which is just detail of the earlier diagram. These are the emplacement drifts at an elevation below the performance confirmation access and the performance confirmation drift itself with drilling alcoves so that the boreholes can be gotten in.

[Slide.]

MR. BOYLE: The next figure is actually just a single figure perspective of all those cross sections and plan views I showed you. Here are the emplacement drifts at a higher elevation

Here's the observation drift with drilling alcoves with boreholes in blue for instrumentation around the six emplacement drifts related to that observation drift.

As I had mentioned, for these six drifts we'll get more information than the drifts that don't have observation drifts above them, but for each and every emplacement drift we will get information.

Dan showed the remotely operated instrument that can carry in cameras, infrared and visual. Similar devices are being tested in the drift scale test. We will have three cameras in use in the drift scale test up to 200 degrees C.

Also, all the emplacement drifts will have their ventilation air monitored in case there is a leak; also to measure relatively humidity.

Other instrumentation is possible in the drifts themselves.

[Slide.]

MR. BOYLE: Also on the agenda was other options considered.

Here is a three-level layout, exhaust main below emplacement drifts with the observation drifts above. But in this option the observation drifts are laid out parallel to the exhaust main rather than being parallel to the emplacement drifts.

[Slide.]

MR. BOYLE: There was another option considered where they are laid out on the bias, if you will. In this system each and every emplacement drift at least has some part of an observation drift above it but no one, two or six emplacement drifts have extended coverage from an observation drift with that layout.

[Slide.]

MR. BOYLE: This is just a detail of that layout to show you that emplacement drifts here, the observation drift on the bias above with boreholes drilled above and down to the emplacement drifts.

[Slide.]

MR. BOYLE: Here is another option considered. If five drifts aren't enough, it only takes time and money to put in more. This would provide complete coverage from above. Each emplacement drift could have boreholes drilled towards it.

Whichever of those options was considered, whether parallel to the emplacement drifts, five or 26, or perpendicular to the emplacement drifts, there are these other options that can be used as appropriate.

[Slide.]

MR. BOYLE: There are two cross sections and one plan view. At the top you can see the exhaust main with monitoring boreholes drilled up alongside the emplacement drifts.

In the middle, this is one of the ventilation drifts that Dick Snell talked about before, and we can use those for instrumentation, drilling boreholes below and above the emplacement drifts. This is exactly what was done in the drift scale test.

If you ignore this part of the diagram, this is the access observation drift; that's the heated drift, and we have boreholes drilled above and below the heated drift itself.

[Slide.]

MR. BOYLE: This is a plan view of a perimeter main emplacement drifts with waste packages, and boreholes can be drilled in the pillar of rock between emplacement drifts parallel to the drifts themselves. This also was done in the drift scale test. We have four parallel boreholes, two on either side of the heated drift itself.

So these concepts can be used no matter which of the other concepts is chosen.

[Slide.]

MR. BOYLE: Performance confirmation facility design is designed to permit implementation of the performance confirmation program; it is integrated with design of the entire system; it is flexible and can be modified to match options in the system, some of the alternatives that Jack Bailey brought up; and the PC facility design will work as designed but will evolve with time as the design, modeling and assessments evolve.

There was a question on the agenda as to what sort of decision process was followed. No formal decision process was followed to come up with the five drifts. It was more of a consensus of the people who worked on it and it was not three people in a dark room, as Jack Bailey had mentioned. The report that came over to the Department was signed by 24 different people in the M&O either as a preparer, reviewer or checker. So it was a consensus of that group that it would work.

It's my understanding informally that they did consider a more formal ranking of the options but didn't follow through on it because, although the costs are reasonably easy to come up with, it's more difficult to value the benefits of the different alternatives. So they did not go with the formal system, although that is not to say that we couldn't in the future.

I am going to try to answer some questions now that I think might come based on some of the questions that have already been asked earlier today.

With respect to Dr. Cohon, the five drifts is not a hard number nor is the number of drilling alcoves per observation drift. It was just a consensus feeling that that would work, although those are not hard numbers.

With respect to Jack Bailey's alternatives, if the design is changed, PC will change, and I haven't seen anything in the alternatives that would prevent PC from working.

With respect to Dan Bullen's question, if we had a repository that allowed people in the drifts, I think, as you had observed, the performance confirmation observation drifts probably would go away, and I think, as Jack had said, nobody had put pencil to paper and calculated the costs and the tradeoff.

But based on many questions I've heard here today, I think from Dr. Sagues, Professor Craig, Mr. Arendt, Chairman Cohon, Professor Peterson, what do you do in the case of accident?

That, I think, is a more difficult thing to put a value on. It's how much benefit is there gained by going with a simpler system that will allow you to go in and recover much more easily from an accident. I think that might drive the answer much more so than performance confirmation changes might.

I think that's the end of my presentation. Questions?

DR. ARENDT: Additional questions?

DR. NELSON: Given that we can expect variability in rock conditions and that the plan is to install precast concrete lining, which I imagine would be close behind the tunnel boring machine -- this is a fairly organized design for PC in terms of where things are going to be -- how flexible do you imagine it to be in terms of being able to be opportunistically responsive to variations in the ground conditions that may require modification from this design? There is a limitation on what kind of modifications you could do off of some of those kinds of designs.

MR. BOYLE: Once the PC drifts are in, and then if we find out that one of the emplacement drifts runs into perhaps unusual conditions that we want to monitor more closely, if that emplacement drift does not fall underneath one of the five, then we are going to have to get the answer some other way through instrumentation in the emplacement drift itself or from the exhaust main below or some other way. Or we can add in another PC observation drift. It would be a significant expense to do that.

DR. NELSON: When will these drifts be put in?

MR. BOYLE: I'd have to defer to Dan McKenzie on that.

MR. McKENZIE: The sequence right now calls for a PC drift to be driven a year or two or three before the emplacement drifts below it are driven. So it would be there before the emplacement drifts but not a long time before.

DR. NELSON: These are not going to be lined?

MR. McKENZIE: Not necessarily. I couldn't say for sure, but since we are going to be excavating alcoves out of them and everything, it may be more of bolt and mesh or shotcrete kind of thing. They are not going to be emplacement drifts, obviously.

DR. NELSON: In order to make the observations that might lead you to modify or respond to changing ground conditions, you are not planning, as I understand, on making any direct observations on every single drift during excavation when you put in precast concrete segments. These are for the drifts.

MR. BOYLE: No, that's not entirely true. We've had many discussions about this. We had a meeting with the NRC last week on the whole concept of mapping the repository.

As it is now, all the perimeter mains would be mapped, plus or minus probably less than what we did in the ESF.

The performance confirmation observation drifts would be mapped to that level of detail.

The ventilation drifts could be mapped to that level of detail if precast concrete isn't used in them and they go with cast-in-place to allow the mapping.

One out of every ten emplacement drifts would be mapped at some level of detail. That leaves 90 percent of the emplacement drifts that I have always maintained would be mapped but not at a level of detail that the other 10 percent of the emplacement drifts nor the perimeter mains would.

A TBM can be built such that there is a window such that a geologist and/or geotechnical engineer can observe the conditions and note, yes, I'm still in the middle, non-lith; no, there isn't any abnormal water; there isn't abnormal fracturing; and write that down. In that sense, knowing where they they are at and what they are in and it's not abnormal, 100 percent of the drifts will be mapped, but it's just the level of detail.

DR. NELSON: In fact you could decouple the precast concrete segment to be almost a second pass lining system if that's what you wanted to do.

How does this system incorporate the ECRB?

MR. BOYLE: The diagram I showed it was not, because when that diagram was finished the ECRB was still in a state of flux. The ECRB will be incorporated as appropriate. It will be there; it will be in the same plane as the observation drifts. So in a sense we will have a mix of five parallel and one on the bias, and it can be used as appropriate.

DR. NELSON: There's been a lot of talk about the precipitation that would occur in the rock immediately above the openings, the water coming back down or precipitation occurring. How would you evaluate that from the drifts? Do you think that is something that you are going to try to confirm about the way the mountain acts?

MR. BOYLE: Sure, and we can use the large block test as an example of what we might see, and also the single heater test. In the single heater test we had one packed off section that collected liquid water. We can have packed off sections and boreholes from the observation drifts.

In the large block test itself the temperatures were quite indicative of moving water, and we can have many thermometers in the boreholes to see that.

DR. NELSON: In terms of whether something is precipitating.

MR. BOYLE: You mean minerals?

DR. NELSON: Yes.

MR. BOYLE: That's a different story. If there is liquid water, we can get specimens of the water out and analyze what's in the water and hope to gain some knowledge of what might be precipitating or dissolving, and we can always drill back. If you think that some sort of precipitation is going to go on during the lifetime of performance confirmation, we can take drill rigs back in there 30 years after emplacement, drill holes, grab the core, and take them back to a lab and see what did dissolve and what did precipitate.

MR. DANKO: Bill, I view these performance confirmation drifts as a tremendous asset to ventilate the repository. In the postclosure ventilation, these drifts can be used as cooling drifts.

Here is my question. In the preclosure period, if you use just about the same amount of excavation and use these tunnels or drifts to move fresh air and ventilate the drifts, would you still need the performance confirmation drifts? In other words, if you keep the repository below 50 degrees C, can you do the confirmation measurement right in the drift?

MR. BOYLE: Yes. The lower the temperature, that solves one of the problems, the heat. We also have a radiation problem. One advantage of the observation drifts above with boreholes drilled from above in observations drifts that temperature is not a problem and radiation isn't a problem is we can go do other things in there, like drill more holes; we can get our instruments out and recalibrate them.

If you keep the temperature down in the repository but don't do anything about the radiation, then we have that difficulty of we still can't back in the drifts if we want to recalibrate something or drill something.

If you can solve the radiation and the temperature, as I had mentioned and Dr. Bullen had mentioned earlier, we can do all the performance confirmation from within the repository itself.

MR. DANKO: Thank you.

DR. ARENDT: Dan.

DR. BULLEN: If you build the confirmation drifts the way you are, you don't expect a thermal pulse to get there?

MR. BOYLE: It does. The repository designers have done thermal calculations to see what effect the ventilation and other performance --

DR. BULLEN: But you will ventilate it while you are in there doing the confirmatory testing.

MR. BOYLE: Yes.

DR. BULLEN: But when you are not in there, it's going to be hot?

MR. BOYLE: I think we are going to ventilate all the time.

MR. McKENZIE: The concept is to ventilate. I actually have some charts that show the thermal pulses. It moves up through and past where the PC drifts are, but if you pump air through in the range of 5 to 10 cubic meters per second, you can keep the PC drifts very livable. We have to anyway because there is a lot of instrumentation in there that don't want to get too hot.

DR. ARENDT: Two final questions from our consultants.

MR. KUHN: One question which is heavily discussed in Europe is safeguarding the repository. Any discussion going on here? Any provisions foreseen?

MR. BOYLE: I'm uncertain as to what the term means. Dick Snell has his hand up. Thank goodness.

MR. KUHN: Safeguarding for misuse of fissile material.

MR. BOYLE: I don't follow it closely. All I know is the license application requires a whole section on how the material is going to be safeguarded. Maybe Dick can address that.

MR. SNELL: We have a security and safeguards program which will be in place for the repository. At the present time we are looking at two aspects of it.

First of all, we are looking at what the physical boundaries are for the repository, the area which is going to have to be protected under security and safeguards, and we are also looking now at what criteria will apply for security and safeguards.

There are several agencies that are going to be involved. Some of the issues will be associated with Department of Defense or Defense Programs under DOE. There is some navy material that we have. There are also some rules associated with IAEA oversight activities which will probably be coming into play. Then there is some DOE rules of their own as an agency with regard to security and safeguards of materials. We are collecting all of those and looking at physical security limits.

I just had a comment here on the side: don't forget the NRC who also has some concerns in this area.

There will be a formal program in place. Right now it's getting what I would say is a fairly limited amount of attention. It's getting enough so that we know we have the subject adequately covered. It will get increased focus as we go towards the license application.

MR. PETERSON: Not a question. Occasionally I'm optimistic. I would suggest that you might want to put in a couple of those drifts, but by the time you finish construction and certainly during the lifetime of the performance characterization, you'll have smart drilling that can reach anyplace you want in that thing from the ventilation drift beneath it at any time you want. You don't need a big tunnel to get in there to do the testing you need.

MR. BOYLE: I agree 100 percent that people will get smarter ten years from now, 20 years from now. We have a design that will work now, but 100 years from now, is that what you'll see? I doubt it.

MR. PETERSON: Twenty years from now, if you put some of that drift money into the research, you'll get it sooner.

[Laughter.]

DR. ARENDT: One more question.

DR. PARIZEK: When the east-west drift diagonal was first proposed Bullen was quite upset as to whether that would threaten the usefulness of the repository. Today we hear five in additional to the diagonal, which makes six. So now the question is whether these can service fast pathways somewhere in the future.

I guess we need to hear about whether or not the refluxing in some way could accumulate in these and pour water in below that is really harmful. We haven't heard any discussion about that.

Dan, you seem to be awful quiet as if you probably learned something I didn't learn.

It's troublesome in a way. Are we opening this thing up to too much access?

MR. BOYLE: If you believe that water going back in the emplacement drifts is bad, these drifts are sloped, and if they do start collecting liquid water, off it goes.

DR. PARIZEK: It trickles off.

MR. BOYLE: Right.

DR. PARIZEK: Then it goes down to the east and slopes back down to the west and accumulates down in the repository?

MR. BOYLE: I'm sure it would be pumped out.

MR. McKENZIE: In preclosure, obviously there is not going to be any water left standing. You will pump it if you find it. Postclosure the concept is that everything drains. The PC drifts as well as the emplacement drifts drain out from the center to the east and west mains and then everything is sloped down to the north slightly so that everything drains to the north. At the north end of the block is where the water stops, assuming you get that much water that it actually flows.

The concept is simply to keep water from ponding where there is waste, and that really is pretty simple.

DR. PARIZEK: And then decide what to do with it later, I guess.

MR. McKENZIE: It's postclosure. It's going to percolate downward. We're not going to be there. That's the concept.

DR. BULLEN: Just to answer your question, Richard, I talked off line about the determination of importance evaluation and I'm waiting to see that before I raise the flag again. That's schedule to come out early next year or perhaps sooner. Maybe we will hear about that at our next Board meeting.

MR. BOYLE: I'll say this. I haven't seen Peter Hastings' calculations either, but I would challenge anybody. Plot up the mountain at a true scale, no exaggeration, and put in the emplacement drifts and the performance confirmation drifts. They are just little pin pricks, essentially. Given the fractured natured of the rock, I find it hard to believe how they really could have an impact. The water will just drain through the fractured rock for the most part. But I'll wait to see Peter's calculations.

DR. ARENDT: I will turn the meeting back over to our chairman, Jared Cohon.

CHAIRMAN COHON: This is now our public comment period. As of 30 minutes ago no one had signed up to make a public comment, and that's still the case.

Would anybody like to make a comment, public or otherwise, signed up or otherwise?

[No response.]

CHAIRMAN COHON: Seeing none, let me thank all the speakers again for participating today. It was a very stimulating and useful day.

We stand adjourned until 8:30 tomorrow morning in this room.

[Whereupon, at 5:20 p.m., the meeting was recessed, to reconvene at 8:30 a.m., Thursday, October 23, 1997.]