NUCLEAR WASTE TECHNICAL REVIEW BOARD

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PROGRESS WITH YUCCA MOUNTAIN EXPLORATION AND TESTING AND THE UNDERGROUND REPOSITORY CONCEPTUAL DESIGN

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Days Inn Crystal City
2000 Jefferson Davis Highway
Arlington, Virginia 22202

Thursday, October 10, 1996

The Board met, pursuant to notice, at 8:30 a.m.

BEFORE:

JOHN E. CANTLON, CHAIRMAN
CLARENCE R. ALLEN, BOARD MEMBER
JOHN W. ARENDT, BOARD MEMBER
GARRY D. BREWER, BOARD MEMBER
JARED L. COHON, BOARD MEMBER
EDWARD J. CORDING, BOARD MEMBER
DONALD LANGMUIR, BOARD MEMBER
JOHN J. MCKETTA, BOARD MEMBER
JEFFREY J. WONG, BOARD MEMBER

PARTICIPANTS:

PATRICK A. DOMENICO, CONSULTANT
ELLIS D. VERINK, CONSULTANT
WILLIAM D. BARNARD, TECHNICAL STAFF
SHERWOOD CHU, TECHNICAL STAFF
CARL DIBELLA, TECHNICAL STAFF
DANIEL FEHRINGER, TECHNICAL STAFF
RUSSELL MCFARLAND, TECHNICAL STAFF
DANIEL METLAY, TECHNICAL STAFF
VICTOR PALCIAUSKAS, TECHNICAL STAFF
LEON REITER, TECHNICAL STAFF
MICHAEL CARROLL, STAFF
HELEN EINERSEN, STAFF
LINDA HIATT, STAFF
FRANK RANDALL, STAFF
VICTORIA REICH, STAFF

P R O C E E D I N G S

[8:30 a.m.]

DR. CORDING: This morning we are continuing with our discussion and with the presentations on repository operations. Our session will continue with a break but will continue through to approximately 1:00 p.m.

As we normally do, we will have an opportunity for public comment at the end of the session. We have reserved time within the program for comment and questions from the Board, and if time, from others in the audience after each of the presentations. So we are hoping again to have good discussions or time for those discussions this morning.

Let's continue with repository operations. We received a summary yesterday of the overview of the repository operations which identified a number of issues. Some of those issues we will be discussing this morning.

The first presentation will be by Jack Bailey, who was giving the presentation yesterday. The first topic is on retrievability issues.

Jack Bailey is deputy operations manager for the engineering and integration for the M&O.

Jack.

DR. BAILEY: Good morning.

[Slide.]

DR. BAILEY: As I showed you yesterday, we had a series of key design issues throughout the different stages of the operations of the repository.

[Slide.]

DR. BAILEY: This morning we are going to talk about retrievability, which as you can see can take place at any time in the waste emplacement up until the closure and decommissioning.

[Slide.]

DR. BAILEY: It is always nice to start with a definition from Part 60:

"The geologic repository operations area shall be designed to preserve the option of waste retrieval throughout the period during which wastes are being emplaced and, therefore, until the completion of a performance confirmation program."

[Slide.]

DR. BAILEY: As such, we have what we call our retrievability issue, which goes on a little while. We look at the development of the retrieval strategy: How easy do we want retrieval to be? Because of retrieval we have to make the emplacement of the waste such that we can get it back out after we have placed it in. Because of the large package size we are looking at, clearly we want it to be reasonably accessible.

We need to look at the credit off-normal scenarios for retrieval that are based on the design that we have; under what conditions do we actually have to get it out.

We need to look at the development of the equipment and the concept of operation of that equipment to deal with these off-normal operations.

We have to develop scenarios for retrieval for reasons of recovery of resources. What if we have to empty the entire repository out? We have to be able to deal with that situation.

[Slide.]

DR. BAILEY: On the lower level we have to deal with the characteristics of the emplaced waste. There is both heat and radiation. As we said yesterday, the drifts may be as high as 200 degrees. Clearly we don't want to go into a 200 degree C environment to recover the waste. We have to have a means by which to handle that.

Of course there is a radiation environment associated with the spent fuel. The long duration of the retrievability period from the beginning of emplacement until closure of the repository causes a great emphasis to be placed on the engineering of the structure that houses the material so that we can get in and get it out in a reasonable period.

Finally, the weight of the waste package can be up to 60 metric tons. It's a very large piece of equipment that we have to move around.

[Slide.]

DR. BAILEY: What are the impacts?

As I started to allude to, the subsurface layout is heavy influenced in order to have access to the packages so we can come back and get them. The whole idea of a horizontal repository with a large package so we can get back and forth to the waste package is driven by that.

The emplacement mode so that we can grip them and remove them should we need to.

It is desirable that the emplacement equipment be set up so that we can emplace it and remove it utilizing the same equipment. That would make some sense rather than having to have a new specialized piece of equipment to get it out.

The ground support to avoid the problems of rockfall and the problems of covering the package and allowing easy access. If we can make a robust ground support system, that would make retrieval much easier.

Ventilation system, as I alluded to, in order to cool the drifts down so that we can get at the packages is desirable.

The retrieval equipment itself for the off-normal conditions. How do we deal with a package that perhaps is broached, has radiological problems, heat problems, ventilation problems, and have to dig it out. So some of the equipment is going to be very specialized perhaps based on what the off-normal conditions say.

Finally, surface facilities in order to store the waste packages either in small number because of problems internal to a waste package or specific to a specific waste package, or perhaps to unload the repository.

So several aspects of the design are impacted by the retrievability issue.

[Slide.]

DR. BAILEY: What have we done recently? We talked a about this a little bit yesterday.

The addition of the central exhaust main to the repository and the ability to operate from either end has helped us a good deal in this. In other words, because of the central exhaust main we can now cool half a drift in either direction so that we can cool the drift down into the 50 degree C range. That was a question from yesterday: what would we really expect to operate in? More in the 50 degree C is what we would expect the equipment to operate in.

If we can get into the drift and ventilation is available, then we can go half a drift, ventilate that. We also only have to travel a half a drift. The old design which basically had entry and ventilation from only one end prevented us from doing that. We could have perhaps 1000 meter drift that we would have to go through in order to retrieve where now we have cut it back to 300 or 400 meters maximum in order to get to any individual package.

It also will shorten the amount of airflow necessary to cool down a drift in order to get to it.

[Slide.]

DR. BAILEY: Another piece of the design that we have changed is the gantry/pedestal emplacement method that we discussed briefly yesterday.

[Slide.]

DR. BAILEY: Here we have yet a different picture of it from the side view which shows the gantry going in, picking up and dropping off on small pedestals for the emplacement where the gantry rides on rails slightly above the pedestal that it is emplaced on.

Retrieval in this manner is again enhanced because the gantry can be maintained outside of the drift, and if there is no upset, the gantry can be sent in remotely to pick up the package and bring it out. The old design from the ACD allowed for wheels on railroad cars, which of course you couldn't leave for 100 years and guarantee their operation. In this manner we feel we have a much better means of going in and getting the waste out and there are no moving parts in the emplacement drift environment.

[Slide.]

DR. BAILEY: Finally, the move to a fully lined drift should provide us with a much lower likelihood of having rockfalls or inability to move the packages throughout the drift. So we feel like we are moving in a certain direction with the design performance assessment with regard to cementitious material in particular that will make the retrievability an inherent part of the design and it into the design very usefully as opposed to being a driver that forces us to do specific type actions.

[Slide.]

DR. BAILEY: The actions for the rest of the year are to do some studies associated with the off-normal events, looking at the design basis events that can affect the waste package in a drift, to identify what the credible events are so that we can design equipment to deal the credible events. The events will most likely include rockfalls and failures of packages, which means that equipment that has to be developed is going to be those things which can dig out a package, deal with the radiological conditions, pick up packages and move them out.

Our intent is to do studies which will take those design basis events, categorize them, and then set up a set of equipment and/or design basis in addition to what we have seen here that will allow us to have a better means of achieving retrieval. We expect to have that study done in May of 1997.

DR. CORDING: Thank you very much. It seems that the opportunity to gain access from both sides of the drift gives you a lot of flexibility not only in operation but the possibility of retrieval. So if you are blocked in one direction, you have the other way to work into the drifts.

DR. BAILEY: Yes. It allows for good construction method, for emplacement and as well for retrieval. A great deal of flexibility.

DR. CORDING: Comments?

Clarence Allen?

DR. ALLEN: I hate to sound like a broken record, but again I would emphasize that both in emplacement and in retrievability one must face the problem of earthquakes that will certainly occur over a period of 100 years in the drifts with accelerations approaching if not exceeding 1 G. I presume it involves somehow tying these things down and being able to untie them at such time as we go in for retrievability. So I just urge that this issue not be put off until too late in the planning procedure here.

DR. BAILEY: No. Your question is well founded. As we go through our design basis advance we will be looking at what the maximum seismic event is that the package would expect to see and whether or not that creates a dislodging of the package from the mounts. We will take either a preventive action to keep it from moving or mitigative action to be able to recover it. That would be one of the events that would be considered, and I failed to mention it.

DR. CORDING: Jared Cohon.

DR. COHON: With regard to the design basis events, could you say more about how you are going to characterize those, and who is going to be involved in that?

DR. BAILEY: The design basis event program is an ongoing effort at the project right now. We are looking at what the design is that we are going to utilize for the repository since frequently events are tied to the design, the processes to identify the naturally occurring events, and then the site occurring events or operationally occurring events and to make up basically a very large list. That list then goes through and gets evaluated by the engineering department, and if necessary, the natural list with regard to issues like seismic or climatology.

In fact we have a team established that does this very thing. We walk through each one of the potential events and make a determination as to whether or not it has a probability of occurrence that is high enough that it warrants review.

Of course we take into account the very low probability and high consequence nature for some events, and some events, if there is a very low probability of occurrence, we don't include it. We basically make up a list along that line. It is handled within the project. Once that list is done and approved, then that becomes our set of design basis events.

Is that responsive to your question?

DR. COHON: Yes. That's a very good response. It raises another question, though, and that is that probability which is low enough so that you can safely or confidently not deal with a design basis event.

DR. BAILEY: You are correct. The choice of a probability is a tough issue. The Part 50 part of the NRC regulation generally sets some criteria associated with classification of events. There in fact is a rulemaking ongoing with the NRC that discussed what kind of a probability we should be looking at and what type of events we should be having. We are trying to stay within those guides and work in that area to keep ourselves consistent with regard to the NRC.

As I have said, we have to look at an event both for its probability of occurrence and for its consequence. If you have the very low probability with a very high consequence, then it's an event that we have to consider.

DR. CORDING: John Cantlon.

DR. CANTLON: Sorry to have missed yesterday's presentation, but earlier the model was to have remote equipment doing the retrieval. Are you still wedded to that?

DR. BAILEY: Yes, we are still wedded to the remote retrieval. In fact there is a discussion on that a little bit later today.

DR. CANTLON: The question then arises in terms of the reliability decision in terms of the tradeoff using remote handling equipment versus somewhat more robust shielding and somewhat more dependable ventilation, which would get your temperature and your radiation problems in control. Is there any thought being given to that because of the problem of reliability on remote handling stuff?

DR. BAILEY: Yes. The question associated with the design basis events is what I go back to. In terms of a straight retrievability, let's take some packages out of an existing undisturbed drift. Remote retrieval is certainly appropriate. We can send the gantry in; we can pick it up; we can look with TV cameras; we can do everything we need and take it out.

When you get to the off-normal conditions and you have to go in and you have to potentially move rock, you have to produce specialized ventilation systems to be able to do with perhaps a broached waste package, an upset waste package that may not be in a condition or an orientation that you can necessarily deal with remotely. Then we would have to give consideration to either sending in the TV cameras and operating hydraulic units remotely. For example, like the old backhoe with different attachments. Send it in and put on different attachments to orient and place it in position.

Our intent at this point is probably to still look at it from a remote point of view because of the radiological hazards and the thermal questions. But as we go through the different design basis events we will make the determination if perhaps an unseen shielded cubicle is a better approach.

So it has not been excluded, but our preference is to lean towards remote at this point in time.

DR. SNELL: If I may add a comment. There is a tendency, I think, with retrievability to think of it in terms of a future "maybe" kind of thing. The point I wanted to make is that retrievability and everything necessary to accomplish it is really an integral part of the design.

When we think about what we are going to do, we have to treat retrievability as almost a normal operational circumstance. Therefore, all the designs that we do and all the analyses that we make are made with the thought that this is something we have to do. We have to think of all the things that you are mentioning.

Seismic is a consideration; the reliability, the availability, maintainability of the equipment; readiness to use it when we have to; upsets that we may have to deal with and odd conditions that we know may exist at the time.

So it is something that will get and is getting full attention and a full treatment, if you will, from an engineering standpoint.

DR. BAILEY: I would expect that the retrievability equipment would be built, placed and maintained on site at the time of license. It is a necessary part. It isn't something that we go build when we find we need it. Some of the aspects of the off-normal will have to be placed in service at the time of the license.

DR. CANTLON: A follow-up question. Are you wedded to the retrievability gantry being a rail-based one as opposed to a tire-based one?

DR. BAILEY: For the reference design for viability assessment we are moving ahead with the railed approach. It doesn't mean that we won't reconsider it in the future, but currently we are going to move ahead for the next couple of years with a railed approach.

DR. CANTLON: The rail approach presumes that an event isn't going to occur to disrupt the rails.

DR. BAILEY: The rail will make us consider an upset event with the rails and make a determination on how to recover from a railed event. We recognize that the railed event is one that we have to consider.

DR. CORDING: Thank you very much.

Our next presentation is on the waste package physical characteristics and the presenter of that is Hugh Benton, who is manager of waste package development for the M&O.

DR. BENTON: Good morning. Thank you.

[Slide.]

DR. BENTON: There are four principal characteristics of the waste package which have primary effect on repository design. Those are the size, the weight, the output in terms of heat, and the output in terms of radiation. Jack Bailey has referred to the waste package as large and heavy, and so for a few minutes I would like to explain how large, how heavy, and why.

[Slide.]

DR. BENTON: I will mention the types of waste for which we are designing waste packages, the disposal container dimensions and its loaded weight, its weight with fuel inside.

I will talk a little bit about the shielding considerations, whether it is more efficient and better to have shielding on each individual waste package or whether it is better to have shielding on the transporter and not have enough shielding on the waste package to provide suitable personnel protection.

I will show you what the current designs are and what the changes are from the advanced conceptual design that have occurred over the last six months.

Finally, just a few items concerning future considerations, possible additions to the reference design that we may consider over this coming year.

[Slide.]

DR. BENTON: Of course we are mindful of the legislative limit of 70,000 metric tons. However, the waste package must be designed to accommodate all 84,000 metric tons of commercial spent nuclear fuel since there is no way for us to know which 63,000 of commercial spent nuclear fuel or which 7,000 of defense high-level waste may come to the first repository. So our designs are intended to accommodate all of the commercial spent nuclear fuel that exists in the 84,000 metric tons.

That commercial spent nuclear fuel exists in 293,000 assemblies of which 126,000 will be PWR and 167,000 will be BWR.

If we were to put all 84,000 metric tons into waste packages with 21 PWRs and 44 BWRs per package, that would take about 10,000 waste packages, 6,000 for PWRs, 4,000 for BWRs.

I mentioned the waste packages for canistered commercial spent nuclear fuel. We also have as a third type of waste canisters for the vitrified defense high-level waste.

The Navy spent fuel we are calling out as a separate category because it is unique. It is exceptionally robust; it is fairly small in terms of weight. There are only 65 metric tons of uranium in the Navy inventory. But it occupies a large volume, 888 cubic meters, which is over twice the volume of the next largest category of DOE-owned spent fuel. So we are thinking of Navy spent fuel as a separate category.

Then, finally, we have the rest of the DOE-owned spent fuel which we are expecting will arrive in sealed canisters. There are 2,670 metric tons of other DOE-owned spent fuel of which about 2,100 metric tons is N-reactor fuel.

We are doing some testing on N-reactor fuel to determine its pyrophoricity or whether it is a pyrophoric problem. The N-reactor fuel is low enriched and there is essentially no criticality problem.

The remaining 570 metric tons of DOE-owned spent fuel is in a large variety of types and categories, as many as 150 or 200 individual types which will eventually have to be individually analyzed. However, we have divided these into nine general categories for the current state of our analysis.

[Slide.]

DR. BENTON: Let me show you a little bit about what the current designs are. This is the design for PWR uncanistered fuel. It has an outer barrier and an inner barrier. The outer barrier is 100 millimeters thick of carbon steel A516, a corrosion-resistant inner barrier of high nickel alloy, alloy 625, and I will explain in a few minutes why we have gone to that.

Both the bottom and the upper covers are of the same two materials, a corrosion-allowance material and a corrosion-resistant material.

The outer barrier and the inner barrier are fabricated together by a shrink fit method in which the outer barrier is heated, the inner barrier is pushed into the expanded outer barrier, the outer barrier is allowed to cool and shrink around the inner barrier.

We have a robust design of basket consisting of interlocking plates of stainless steel boron. The boron, of course, for criticality control. And individual tubes of carbon steel for each assembly.

There are also structural members around the side to keep the basket structure in place.

That is the general shape of our current 21 PWR waste package.

[Slide.]

DR. BENTON: We have a companion one which holds 44 BWRs. This size was selected because the diameter is approximately the same as the 21 PWR and we would like to keep all of the sizes as consistent as we can. This has the same corrosion-allowance outer barrier and corrosion-resistance inner barrier as for the PWRs. It has the same basic design basket with support structure and interlocking plates of stainless steel boron.

[Slide.]

DR. BENTON: For canistered spent fuel we have somewhat of a generic design design because we are not sure at this point what exactly the canister will look like. It has the same outer and inner barriers, and we are presuming that the canister would hold a 21-PWR and 40-BWR. If those particular capacities don't turn out to be exactly those numbers, it will be no problem to analyze for the disposability of some different canister.

In the absence of a specific design for a canister we are using as surrogates the MPC conceptual design of a couple of years ago and the current Westinghouse design.

[Slide.]

DR. BENTON: For defense high-level waste we have a design which is again selected to be approximately the same diameter as for commercial spent nuclear fuel. It holds four of the Savannah River style pour canisters of vitrified borosilicate glass. It has a guide to facility the insertion of the canisters. It will probably have a separator plate at the top to keep the canisters in place.

[Slide.]

DR. BENTON: The final basic type of design is a proposal for the co-disposal of DOE-owned spent nuclear fuel with defense high-level waste. This adds one additional Savannah River sized pour canister to the waste package so that there is a ring of five. That leaves room in the center for a canister 43 millimeters in diameter for DOE-owned spent fuel.

This particular design of basket would accommodate 27 research reactor assemblies in three stacks of nine each. However, this basic canister in the center would accommodate a fairly wide range of the DOE-owned spent fuel. We might have depleted uranium inside this central canister to help with our criticality control problem for some of the highly enriched DOE-owned spent fuel. We could also have depleted uranium outside of the central canister in among the five pour canisters for the same purpose.

The co-disposal has the advantage that in the degraded mode as the waste package proceeds from its intact configuration toward the eventual ruble pile in the bottom of the drift the presence of the corrosion products from the pour canisters helps to dilute the effects of the highly enriched DOE-owned spent fuel.

[Slide.]

DR. BENTON: As to sizes, dimensions, these are essentially the dimensions of the five different types of waste packages that I have shown. The dimension which would control the design of the repository in both diameter and length is currently the canistered 21-PWR for commercial spent nuclear fuel.

As I mentioned, we are not absolutely sure of these dimensions because we are having to use a surrogate for what the eventual canisters will look like.

If we should decide to proceed with this proposed waste package for the co-disposal of DOE-owned spent fuel with defense high-level waste, that is slightly larger. That would increase the diameter to two meters, and that would then become controlling. As you will note, the defense high-level waste canisters are much shorter, so the length is not a problem, and they are also much lighter, as we will see shortly.

[Slide.]

DR. BENTON: These are the weights in metric tons for disposal containers loaded with their appropriate fuel but without any filler material.

Again we see that the heaviest weight by far is the canistered 21 PWR container for commercial spent nuclear fuel. It is much heavier than the heaviest of the uncanistered designs.

[Slide.]

DR. BENTON: Let me mention some of the changes that have occurred in the waste package design since the March 1996 advanced conceptual design report.

First of all, I mentioned the fabrication method of heating the outer shell and pushing the inner shell into it and then allowing the outer shell to cool.

The alternative was to clad the inner shall material, the corrosion-resistant material, onto the inner surface of the corrosion-allowance material.

We believe both of these methods would give us the appropriate level of galvanic protection, galvanic protection being necessary to ensure that until the outer shell is nearly totally corroded away we do not have galvanic corrosion occurring on the inner shell.

The primary difficulty with the cladding method is cost and the cost difference is about $56,000 per waste container. We believe this method would not only save the $56,000 but also will give us an appropriate level, a very good level of galvanic protection.

However, it hasn't been tested. We must assure that we can do this. This has been done commercially. A company in Cleveland called the American Tank and Fabricators has performed this operation in sizes that are consistent with what our waste package will be. One other company has done it in pump casings, which is a little different, but is confident that it can be done. However, nobody has done it on a production scale, and we have to do this thousands and thousands of times with an extremely low defect rate and the ability to determine where the defects are so that they can be corrected.

The second one is the change of the inner barrier material from alloy 825 to alloy 625. We are quite convinced that alloy 825 would satisfactorily meet our requirements. However, alloy 625, both of these being high nickel, highly corrosion-resistant alloys, and the difference being that alloy 625 has a higher molybdenum content, alloy 625 is more corrosion-resistant in severe environments, particularly very low pH environments such as we might encounter with microbiologically influenced corrosion.

However, the alloy 625 is a little more expensive. It has increased the cost of the total waste package in the 21 PWR size by $31,000. We judged that the improved performance is worth that additional cost.

We have changed the basket support and tubes from stainless steel to carbon steel. The advanced conceptual design had stainless steel. This was one of our earliest changes after the ACD report came out. We were fairly sure before then that we wanted to do that, but we had not had time to do the analytical work of the thermal considerations and the structural considerations to show that going to carbon steel was the right thing to do.

The carbon steel gives us better strength; it gives us thermal conductivity which is improved; and there is a reduction in cost of about $35,000 per container.

A fairly significant change was to move from copper nickel to carbon steel for the outer barrier of the defense high-level waste containers. Our advanced conceptual design had copper nickel for the outer barrier because of concern that the iron from the steel would have a deleterious effect on the dissolution rate of the glass.

There is no question that it does have some effect on the dissolution rate. However, our analysis and our computations have now shown that because there is a fair amount of iron around anyway from adjacent waste packages and these are intended to be emplaced between commercial spent nuclear fuel waste packages that we are able to go to the carbon steel without any significant increase in the overall dissolution rate of the glass.

This not only gives us a performance assessment advantage because we don't have an entirely different system to analyze for performance, but it also has a significant cost saving of about $67,000 per container.

Finally, we are evaluating DOE-owned spent fuel containers. I have shown you a picture of one. We also have conceptual designs for the emplacement of DOE-owned spent fuel in their own independent, individual and small waste packages which likely would include depleted uranium as a diluent.

In addition to the research reactor fuel designs we are working on a conceptual design for the Shippingport PWR fuel and for Fort St. Vrain fuel.

[Slide.]

DR. BENTON: If I could turn now to the shielding situation. The waste packages will have a fair amount of shielding. They will have 120 millimeters of steel of one sort or another shielding around the fuel, which does cut the radiation dose significantly.

However, even with that the design basis waste package with 21 PWRs will have these types of radiation dose in rem per hour. On the surface 30 rem per hour, 2 meters from the surface, 5. The defense high-level waste package have even a higher dose rate of 65 rem per hour at the surface and 20 rem per hour 2 meters from the surface. This compares with a normal administrative limit of 5 rem per hour per year for a radiation worker.

So without some additional shielding a person in the emplacement drift would essentially receive four times his annual dose in the first hour, clearly not desirable.

[Slide.]

DR. BENTON: The question is whether shielding should be provided on the individual waste packages or whether we should provide shielding only on the transporter and essentially restrict personnel from loaded drifts.

Clearly the advantage of shielding the individual packages would be that once the drift was cooled, either naturally or artificially, down to a temperature where somebody could work, such as 50 degrees centigrade, after that you could have limited personnel access if the individual waste packages were shielded.

There are clearly many advantages to being able to allow personnel to go into the drifts, either for drift maintenance, to take care of some off-normal event, to performance confirm that what was happening in there was what was expected, and for a good many other reasons.

The disadvantages of putting the shielding on the individual packages are, first of all, since in general particularly neutron shielding tends to be light it decreases the thermal conductivity markedly. This would increase the fuel temperature. We could exceed our 350 degree centigrade limit on centerline fuel temperature, which would reduce cladding performance and probably eliminate any possibility of being able to use cladding as a viable barrier.

The increased size of the shielding on the waste package would probably require that the drifts be increased.

It's a fairly significant increase in weight, which would make handling difficult.

The shielding would perform a function during the preclosure period but no function post-closure since the rock is an excellent shielding once the repository is closed.

And shielding adds to waste package cost significantly.

[Slide.]

DR. BENTON: Let me put a few numbers on that. This is the 21 PWR design with two types of shielding.

Probably the most practical shielding would be concrete sheathed in stainless steel which would go on all sides of the waste package.

A shielding which would reduce the radiation dose from what I previously showed down to 20 millirem per hour, which would allow a radiation worker to be in the drift about one hour per day without exceeding his annual dose, would have these characteristics. It would increase the diameter by .4 of a meter.

It would increase the weight by 68 metric tons. That is considerable more than a doubling of the weight of the waste package.

And it would be expensive. One reason is we are assuming that we would have to x-ray the shielding to determine that there are no voids anywhere.

There is also some difficulty with neutron shielding. The best neutron shield material can tend to be pyrophoric.

If instead we use carbon steel -- although carbon steel is a poor neutron shield, if you make it thick enough you will shield against anything -- it would take 18 inches of additional thickness of shield in order to reduce the radiation dose rate down to the 20 MR per hour. We don't really believe this is practical, but I will just mention it anyway. This would increase the diameter by nearly a meter; it would increase the weight by over 100 metric tons; and it would be extremely costly.

[Slide.]

DR. BENTON: Let me mention a few future considerations.

From the standpoint of the waste package alone without considering the rest of the system bigger is better until we reach some limit. We are currently designing using a design basis fuel which will accommodate more than 90 percent of all of the commercial fuel that exists or will exist.

Because of that, our design basis fuel has a fairly high thermal output. Therefore, much of the fuel is much cooler than that. So for fuel which was not as hot as the design basis fuel we could increase the capacity of the waste package from 21 PWR/44 BWR to 24 PWR/52 BWR, which turn out to be the next larger size with a very efficient packing arrangement. This would therefore reduce the number of waste packages and reduce the cost of the waste package itself. We would have to evaluate the effect of that on the rest of the system, on the repository design to determine whether this was the right way to go or not.

A fairly minor change that we will probably make is for those waste packages which will have a high thermal output we will probably be adding aluminum shunts in the basket.

For DOE-owned spent fuel we are trying to reduce the cost by looking at reduction, maybe even elimination of the baskets inside those 43 millimeter containers.

We have done a great deal of analysis yet on BWRs. That is scheduled for this fiscal year. We are looking at the minimum practical thickness of the stainless steel boron plates for BWRs that will meet both our criticality control requirements and our structural requirements.

Finally, we are considering methods of providing an additional outer barrier for those repository conditions of high humidity which might occur through a decision to go to a low thermal load or perhaps a high percolation flux.

This has been variously termed "drip shields." Rather than some tent that goes over the waste package and which would then probably be destroyed with the first rockfall or something that would be carried down to the repository separately and set over an emplaced waste package, we are looking at just a continuous outer barrier that goes all the way around. That could either be a fairly thin layer of titanium or a sprayed-on ceramic. In FY97 we will be considering which of these is most practical and we hope to advance our knowledge of the possibility of the use of sprayed-on ceramic.

Subject to your questions, that is what I have on physical characteristics of the waste package.

DR. CORDING: Thank you very much.

John Cantlon.

DR. CANTLON: As you think about these future possible increases in the size, are there any manufacturing limits as you have talked to the people that manufacture the thing? In other words, how big can they make them efficiently?

DR. BENTON: No, sir, we really have not come across any manufacturing limitation at all. Of course when we ask the vendors, they are delighted to make it bigger. The bigger the better. Our own staff analysis indicates that certainly we could make them as big as reactor vessels if we had to. There may be a practical limit of the shrink fit design in which the available equipment in the industry could handle it. But so far no limit.

DR. CORDING: Don Langmuir.

DR. LANGMUIR: We understand there has possibly been some internal confusion in the program insofar as Livermore was setting up to study corrosion of the 825 and all of a sudden discovered that it was now 625 they should be concerned about. I wondered how that is playing in. I gather they have shifted gears rapidly to put the 625 in their corrosion tests, but were they part of the process of deciding which alloy would be considered? I gather they weren't.

DR. BENTON: Yes, sir, they certainly were at each step in the process, and they had both alloys in their plans for long-term corrosion tests. The Livermore long-term corrosion tests includes a test of a very broad range of materials, including materials that have higher molybdenum content than we are now talking about, such as Hastelloy C-22. If later we should decide to go yet the next step, that material would already be in the test vats.

Those material testing tests are getting started right now. We certainly do not expect to select any material which doesn't have samples in those test vats. We are closely linked with Livermore on material selection and material testing.

DR. LANGMUIR: How flexible are you at changing the alloy you might use? You are going through all these calculations now with 625. If they come up with a different alloy -- How many different alloys are they considering?

The other side of that thing, not exactly related, is the pH environment. You talked about it being acid. It might well be extremely alkaline given all the concrete surrounding the site and likely to collapse on the packages through time.

DR. BENTON: We believe that either alloy 825 or 625 would perform about equally in the high pH range.

We are certainly flexible and could change. We will probably by the end of this year decide that whatever material we have is the material for VA, because we want to make sure that all of our analyses are consistent with our design. If later on there should be a need to change, we could do it.

What we are talking about is a fairly minor change in alloy content. We expect the basic design of the corrosion-allowance outer barrier, the corrosion-resistant inner barrier, which has been our basic design for some four year, very unlikely to change.

DR. LANGMUIR: You talked about a whole series of reductions and increases because of the changes in materials in the inner and outer barrier. Where are you in terms of net cost with the current proposed design? Are you $31,000 more expensive if you use 625 instead of 825, $35,000 less expensive because you are using the 516 on the exterior? I got lost in which direction were finally headed, at least at the moment.

DR. BENTON: We are headed toward lesser cost.

DR. LANGMUIR: You think you will be at less cost with the current design?

DR. BENTON: Yes, absolutely.

DR. LANGMUIR: What does that look like for total cost in the repository now?

DR. BENTON: About $350,000 per waste package for the large size, 21 PWR.

DR. LANGMUIR: What does that make the total cost in the repository?

DR. BENTON: If there were 10,000 of them, that would be $3.5 billion. That is the procurement cost. That is not total life cycle cost.

DR. CORDING: Ellis Verink.

DR. VERINK: We were looking over the test setup out a Lawrence Livermore. We found that 625 wasn't in the program yet. Is it planned to be in?

DR. BENTON: Yes, sir. As you know from being out there, they are just setting up those test vats now. In the original vats, the first vats they did not have 625. 625 is in the program and has been in the program. Samples are coming for that and they will be starting. This is a five-year test. So whether it starts a few weeks after the very first samples will not make any difference in the total test.

DR. CORDING: John Arendt.

DR. ARENDT: Is there a limit on the weight of the package? Have you placed a limit on it? If there is a limit on it, how did you arrive at that?

DR. BENTON: We have not placed a finite limit. Any increase in the waste package is being analyzed on a system-wide basis to see what the effect is on the rest of the repository and whether it is appropriate to make that adjustment upward or not.

Clearly anything like adding metallic shielding down to personnel limits would require a massive redesign of everything and is not currently being considered. The repository is being designed for the current maximum size waste package with a reasonable safety factor. We don't have a hard limit imposed.

DR. ARENDT: Have you optimized the size of the package?

DR. BENTON: We are certainly fairly close to optimizing the size. We are now considering such things as, do we achieve overall system cost savings by having a family of waste packages so that up to some maximum size we could put cooler fuel into larger packages and hotter fuel in smaller packages? Or does that create so many complications for surface facilities that that is not the right way to go?

We are down to the point of optimizing the total system through things such as that.

The 21 PWR/44 BWR is clearly about the right size. As I mentioned, we might be able to go just a shade bigger.

DR. ARENDT: Are you considering fillers at all? For example, depleted uranium. Are you doing any studies or do you plan on doing anything?

DR. BENTON: Yes, sir, we are looking at depleted uranium particularly for the highly enriched DOE-owned spent fuel. For the size waste packages that we are talking about for commercial spent fuel we do not need depleted uranium or any other filler for the design basis fuel.

Our design basis fuel is intended to take care of more than 90 percent of the fuel. So that leaves 10 percent which we can handle either by leaving the center assembly out and putting in a blank or by having a slightly smaller waste package or by using filler material or some other ways to control a criticality.

We haven't decided yet which is the most optimal. Depleted uranium is therefore a possibility, but filling up all of the spaces in a 21 PWR waste package with depleted uranium pellets adds a tremendous amount of weight.

DR. ARENDT: The last question may not be appropriate to you but I'm not sure at what point I can ask it today, so I'm going to ask it now.

I am very concerned, as I said yesterday, about the fact that there are no standards of specifications for the transport of packages to an interim storage area or to Yucca Mountain. What interaction is there between the design people in Las Vegas and the people in Vienna? How are you interacting with the transportation people to make sure that you are going to have the design information so that you can design the receiving equipment properly? Are you interacting with them? Is there a time limit as to when that information must be available to you can factor it into the design?

DR. BENTON: We are closely interacting with the M&O in Vienna on all of these questions. So we are closely integrated there.

The integration between either us or Vienna and the individual vendors who are trying to design canisters which they hope to be able to license for disposal is not as far advanced because the vendors haven't yet really decided what their design is going to look like. There are at least four vendors that have said that they hope to have a canister for disposal as well as for transportation and storage.

What we have seen of those designs so far, we don't feel that they are very far advanced as far as disposal, particularly things like criticality control. They do not have long-term criticality control mechanisms in their designs.

The information from the vendors as it becomes available will be available to both us and Vienna and we are working together to know as much as we can about what those designs will look like.

DR. SNELL: A little addition, if I may. We have a regular interface or coordination activity, integration activity as part of our normal scope of work, if you will. Included in that is a regular interface with the folks that have been working in Vienna. The level of effort in that activity has increased substantially over the last year, but there is a regular interface between our folks in Las Vegas and Vienna.

Heretofore that interface tended to focus on the

MPC while it was a viable option. Currently the RSA concept which is being promulgated by DOE is now coming into the picture. That isn't fully fleshed out but a good deal of work is being done on that regional services agent concept. There will be, we expect, specifications produced that will eventually end up in the procurement cycle for the RSA implementation. So on a regular basis, and I'm talking about weekly or biweekly interactions with east and west, we are exchanging information on what they expect to use in the RSA concept and what that means to us from a repository standpoint. It isn't finished yet, but the conversations are active and we recognize the implications for us are substantial.

The other general comment I would like to make on the waste package. I know we have presented a lot of information here on the size, cost, and so forth. The waste package, of course, is central to the waste isolation performance of the facility. So I might comment that any decisions that we make with regard to the waste package designs are, first of all, focused on what is the impact on performance on the repository.

We are doing some study work now to help us in establishing the priorities in design so as to understand which design options give us the most effective performance or the best performance improvements on the various elements, particularly the waste package.

We will make decisions first with a full knowledge of what the performance aspects are. If the waste package doesn't satisfy performance, then nothing else matters. We need to satisfy performance and then we can optimize on cost and other aspects.

The other comment I might make too in talking about package size and so forth, the repository itself tends to impose limitations on us in some respects. Size, for example. If we look at situations where we want to lift one package over another within an emplacement drift, clearly the size of the drift becomes an issue, and if we talk about increasing diameters, we want to do so with full knowledge that we might be having implications for how big the drift has to be and what kind of equipment there has to be.

Likewise in handling. We are talking about heavy packages, as Hugh has pointed out, and heavy packages, while they are within the range of handling capabilities that we are familiar with, are indeed in the high end of the range for handling equipment. So I think we want to look at weights on packages in that light.

Where we can, I would like to see us stay within the range of equipment capabilities that are currently in use, currently known, and that will help us in terms of cost and other considerations as well from the standpoint of what kind of equipment systems vendors can supply without plowing new ground.

DR. CORDING: John Cantlon.

DR. CANTLON: Hugh, I would like to pursue a little bit the basket element of the design. First of all, taking your future consideration, your last overhead, you are talking about the possibility of eliminating the basket.

DR. BENTON: For certain types of DOE-owned spent fuel. Definitely not for commercial fuel. We need the basket to keep the assemblies in place, heavy assemblies.

DR. CANTLON: The loading of those things is going to take place at the utilities.

DR. BENTON: The loading of the DOE-owned spent fuel will presumably take place at INEL and Hanford.

DR. CANTLON: I understand, but the utility spent fuel.

DR. BENTON: Yes, sir.

DR. CANTLON: One of the questions would be, how much are you working with the utilities in terms of that process?

DR. BENTON: Our current reference assumes that the majority of the fuel will come there in transportation casks and will be unloaded from the transportation cask into a waste package at the repository.

DR. CANTLON: But canisterized.

DR. BENTON: Where is a canister design which is submitted to the NRC or licensed by the NRC for disposal, we will certainly be closely plugged in with the utilities that are going to load that to ensure that it is loaded in such a way that it meets the NRC requirements for disposal and doesn't have to be opened.

DR. CANTLON: You are assuming in the early runs out to the storage area that you are going to have to do hot transfers then?

DR. BENTON: Yes, sir.

DR. CORDING: Ellis Verink.

DR. VERINK: I'm not certain what the heritage of the 2 centimeter thickness on 625 was, but would there be any advantage to increasing the thickness of the basket elements and steel to add additional support to the 625 and also to provide heat transfer?

DR. BENTON: And a concurrent reduction in the thickness of the 625?

DR. VERINK: Yes.

DR. BENTON: We have looked at that. We haven't done a full analysis of that, but we will be looking at the optimization of that 625 layer. The 20 millimeters was selected. Our analysis so far indicates that that thickness is about right. It gives us the structural strength we are looking for particularly in those conditions where it is well past post-closure; it's thousands of years. We have corrosion of the carbon steel, which is a robust outer barrier, and then you have rockfall. We want to prolong the life of the waste package by making the inner barrier sufficiently strong that it will withstanding reasonable rockfalls.

We believe that the 20 millimeter is about right, although we will be doing some further analysis this year and certainly before license application we will have more analysis.

DR. CORDING: Russ McFarland has a question.

DR. McFARLAND: In increasing the package size, not only do you increase weight but you are considerably increasing the thermal output. The MPCs had a thermal limit of about 14.5 kw. Wouldn't you now with a 24 PWR be up around 20 kw?

DR. BENTON: No. We would not. We would not expect to increase from 21 to 24 for that commercial spent fuel which had a high thermal output. For much of the fuel 14.4 kw per package was the design basis. The average waste package will have a thermal output of about 9. That means that half of them will have something less than 9. So for the cool fuel it's possible that we could increase, depending of course on its effect on performance and on repository design, as Dick Snell has mentioned. But not for the hot ones.

DR. McFARLAND: There is no particular concern about in the point thermal loading of having, say, a 1 kw package in line with several that could be well into the teens where your temperature variation along your drift would be rather large?

DR. BENTON: We want to ensure that we keep to our limits, 200 C for rock wall, 350 C for centerline temperature. So as we develop the waste package and we develop repository loading schemes we would stay to those limits. In the long run the temperatures tend to level out. Depending on the overall thermal loading, the point loading concept and having a cold package next to a hot package will be considered to make that that doesn't have any deleterious effect.

Dick Snell is going to discuss that when he talks about thermal loading.

DR. CORDING: Carl Di Bella.

DR. DI BELLA: I have a question about your concrete shield, Hugh. You show it with a stainless steel sheathing. Is that to keep the moisture in? What is the purpose of the sheathing?

DR. BENTON: Mostly the purpose of the sheathing is to provide some reasonable handling capability. Since this is a heavy package, if it was just concrete on the outside, we believe there would be a good deal of difficulty in handling it.

DR. DI BELLA: Another question having to do with the highly enriched uranium, that 5-package of defense waste with the HEU in the middle. How much HEU would there actually be in that middle container? Has anyone in OCRWM given consideration to the nonproliferation or diversion aspects of putting that kind of material into the repository?

DR. BENTON: To the second question first. In the overall analysis of the potential disposal of DOE-owned spent fuel the proliferation aspects are being considered. We are contributing to that but we are not central to that. It is being considered.

As far as the amount of HEU that we can put in there, that obviously depends on whether we are going to add depleted uranium or not. If we don't add depleted uranium, we can conservatively put in about 14 kilograms or a little more. After we refine the analysis that can probably be increased some.

DR. CORDING: Jared Cohon.

DR. COHON: I would like to go back to this colloquy that you and Dick Snell and John Arendt had which confused me somewhat. Dick, you said the first consideration is performance. What do you mean by that?

How do you measure performance for this purpose?

DR. SNELL: What I am referring to is performance in the context of TSPA. When I talk about the performance of the waste package, the package itself is simply one element in that whole array of TSPA elements on which we will base the performance for the repository overall. In other words, its ability to satisfy the regulatory requirements. So I was simply referring to the fact that the package being one of those key elements we need to focus on that first.

DR. COHON: Mr. Benton, response to Mr. Arendt's questions you said you were seeking the optimum for the system. How do you define system here and what criterion or criteria are you using to find that out?

DR. BENTON: As has been pointed out, the first element of the system would be the overall performance of the waste package to carry out its intended purpose of containment of the waste, minimization of the probability of criticality, and proper performance in the repository.

A second major consideration is the impact of waste package design on the design of the rest of the repository.

A third consideration for canistered fuel is the potential impact on the rest of the system of canistered fuel coming in and becoming a part of the waste package.

DR. COHON: The system there includes transportation and handling?

DR. BENTON: Yes, it would include transportation and handling.

DR. COHON: But for the first two the system was the repository.

DR. BENTON: The overall repository system, including its performance preclosure, post-closure, and the design of surface and subsurface facilities. We are concerned about the potential impact of waste package characteristics on that system.

DR. CORDING: Woody Chu.

DR. CHU: I have a question that I think is sort of related to the one that Jared just asked and related to one that John Cantlon asked earlier. On the waste package, if you put on the concrete shielding it would buy you a worker's access one hour a day per worker at a cost of $1.6 billion. In the broad sense of the word, in system terms, what does that buy you in terms of operational benefits?

DR. BENTON: This would be a personal opinion, but I believe since the current design appears to be adequate using remotely operated equipment --

DR. CHU: I meant in the sense does that allow you to deviate from the current design of having forbidden worker entry, total remote? Would that allow you to ease up on that? That's what I meant by "in broad terms."

DR. BENTON: Yes. I would think that if you had a radiation environment which only allowed a worker to be in there one hour a day that it would be reserved for unusual reasons for entry. You would probably not want that to be the norm that you expose your workers to that amount of radiation.

DR. CHU: It might give him some benefits to recover from off-normal, though.

DR. BENTON: For off-normal events it would certainly allow access to assess the degree of off-normality and perhaps to plan better how to recover from it. The waste packages are being designed with attachment points at both ends, which are extensions of the outer shell, so that if the waste package is in an off-normal position, we believe that remote equipment can latch on to it and physically drag it out. Clearly if you were able to go in there, that might facilitate that operation.

We can always go in with shatter shielding. We could go in behind temporary shielding that we put in in front of us so that you can at least get to the first waste package with safety.

DR. CORDING: Bill Barnard.

DR. BARNARD: Hugh, I have two questions about heat shrinking shells together. When you begin that operation of inserting your inner shell into the outer shell, how much distance do you have between the two shells?

DR. BENTON: After heating?

DR. BARNARD: After you have heated them and you begin inserting one into the other.

DR. BENTON: I am afraid I can't give you an exact answer, but I will get it for you. I would say probably on the order of a quarter of an inch.

DR. BARNARD: That is close enough.

How much time do you have to complete the operation before the two shells begin to bond to one another?

DR. BENTON: This type of operation is similar to what is done in making large boiler casings, or whatever, in which the material is put into a furnace and heated, which may take hours or even more than a day. When it is taken out they will roll it. Those operations take a couple of hours. Something this thick will cool fairly slowly. It's not a situation where you have to take it out of the furnace and immediately put the inner one in. You would have considerable time. You would want to do it on the same shift.

DR. BARNARD: Thanks.

DR. CORDING: Thank you very much. We appreciate your presentation.

We are ready now for our break. We are a few minutes early. We will break now until ten after ten.

[Recess.]

DR. CORDING: We are ready to continue our discussion on the repository operations. The topic is subsurface remote operations. Alden Segrest is making that presentation. He is the manager of the MGDS development for the M&O.

We will have two presentations. We will have discussion after the first.

Alden.

[Slide.]

DR. SEGREST: This topic has already received several questions, so hopefully the answers haven't given away everything I'm going to say.

Talking about remote operations with the repository, particularly in the subsurface area, the real issue here is the application of remote handling to those operations in the subsurface.

The subsurface environment is characterized by high radiation. You have heard comments on that. If you recall from Hugh's presentation, at one meter from the spent fuel waste package a worker would receive his annual dose in one hour.

The elevated temperatures during the emplacement is not a problem. It's only about 50 degrees C. But when you look at the later temperatures in the emplacement drifts, we are up to a limit of 200 degrees C, which is about like working in your oven while you are baking a chicken.

The confined operating area with all the tunnel operations, even the things we are doing right now within the ESF, there are concerns with the operating area, the space we have to work in. So within the emplacement drifts that would be significant as well.

Then there are access limitations because of this for the maintenance and repair tasks that need to take place.

[Slide.]

DR. SEGREST: Why is the remote operations issue such an important one to the repository subsurface design?

The emplacement drifts themselves take about 90 percent of the subsurface area. So the majority of the area is composed of those drifts.

Under normal conditions, those emplacement drifts will be off limits to personnel due to the heat and the radiation. Once the emplacement drift is closed and no longer continuously ventilated to keep the temperature down, anything that would be done in there would have to be done remotely unless we wanted to go through the time of a week or so that it would take to cool down the emplacement drift to reduce the temperature, and even then we have the problem with the radiation.

The repository design concepts that we are working with heading toward with our VA design rely very heavily on successful implementation of remote systems.

[Slide.]

DR. SEGREST: In planning for the remote operations in the design we are considering transport from the waste handling building at the surface to the emplacement drift entrance. That is just moving down the tunnel with the package, at which time the package will be in a shielded transporter. We do have to move down the grades. It will be a locomotive moving that transporter down to the drift entrance.

I will show you a picture in a moment or two of how it occurs, but the transfer at the emplacement drift entrance is a significant operation to consider. Then we have to consider the emplacement of the packages, and as part of our design we have to consider the retrieval. Knowing that retrieval is a possibility at some point and knowing that we have a requirement to design for retrieval, that has to be factored into the up-front design of how we actually emplace the waste itself.

We have operation of the rail switches and emplacement drift access control doors.

There are performance confirmation tasks which will occur as the repository is being loaded and afterwards that we have to consider. We do not even have those tasks clearly defined yet. That is a challenge in itself.

Then we have the recovery from off-normal conditions. The way we have to design systems for nuclear operations, we of course design them so that the off-normal conditions will not occur, but then when the off-normal conditions occur, we have to design to mitigate or compensate for those conditions.

[Slide.]

DR. SEGREST: Looking at the operations underground, we will look at the haulage, transfer at emplacement, the emplacement itself, and then the possibilities for retrieval and the requirement for monitoring performance confirmation. So I had to have some nice color pictures. I think you have seen this one already.

[Slide.]

DR. SEGREST: This shows the operation at the transfer point. The waste package itself will be moved within a shielded transporter down to the entrance to the drift. Of course we have to have consideration of the various switches, and so forth, getting down there. It is not acceptable that this locomotive could actually have an operator down to this point. We would have to have operation of the doors. There is a set of these doors at each end of each emplacement drift.

Once the transporter arrives in position the doors will have been opened. It will move into position. Then the door on the back side of the transporter has to be opened. The waste package has to be moved out of the transporter into position inside the drift such that the gantry can move into position to lift the waste package to emplace it where it has to be put within that emplacement drift.

[Slide.]

DR. SEGREST: This particular one shows it is the last waste package going into a drift. It's a little bit closer view so you can see a little more of the gantry. You can't pick up all the details of this, but after the waste package is in place we do have a shield wall here, partial wall to reduce some of the radiation coming out here to the drift doors.

One of the issues we are looking at doing some analysis on is not completed yet, but it is what the actual radiation will be in the drift. With the multiple packages along the drift we have got to do some analysis about the reflection within the drift from the radiation from the various packages all the way down the drift to see the impact of it down in this area.

[Slide.]

DR. SEGREST: Here you can see how the gantry would actually lift the waste package high enough so it can move over this shield wall. Currently the design is such that the package can be lifted over other packages. Even though there is not necessarily any reason to do it unless we get into some specific retrieval situations, we do have that design feature in the design at the current time.

[Slide.]

DR. SEGREST: I will tell you that the remote operations issue is something that we have just begun to spend a reasonable amount of time on within the past year. We started on this in FY96. We had done very little on it before then within the design organization.

Some of the recent work that we have done. We have taken a look at available technologies. We have looked wherever we could for the technologies that could be or may be applicable to this underground repository.

We have looked, of course, at the mining industry first, looking at automated mining applications. The one that our folks like to describe. There was a mining show in Las Vegas just a few weeks ago and they were talking about how from the booth there -- the equipment was there -- they could operate trucks in a mine in Australia. There is some precedent in the mining industry for automation. So we are looking at the automated mining applications, particularly those things underground because there are some unique situations underground we have to deal with.

Within the railroad industry there is a fair amount of automation with locomotive and rail systems, particularly in their switchyards.

The primary thing we are looking at in the nuclear industry is what they do within the radiation environment, the type of instruments, equipment, and so forth that they use in the reactor buildings that can withstand the radiation.

There are also a lot of industrial applications for automation, robot manipulators, and various controls.

[Slide.]

DR. SEGREST: We can also look at nuclear waste programs. There has been some work done for the Yucca Mountain project and the waste isolation project in New Mexico.

There is a lot of DOE research that has been done in the past. We are looking at some of that work with respect to the intelligent mobile vehicles and the advanced remote systems.

NASA. We always hear about work that they have done with telerobotics, operator interfaces, and communications. We have looked at that and looked at university research.

So we have looked wherever we thought we could find something that may be a benefit to at least start our initial screen on what would be appropriate for the repository subsurface operations.

[Slide.]

DR. SEGREST: We are focusing our work in several areas, primarily looking within capabilities for remote communication. We want to look at the types of communication we can use with remotely controlled vehicles in an underground environment.

We are looking at the power source technology as well. So we look at the control communications technology as well as the power technology for how to move and manipulate the gantries, how to move the locomotives.

We are looking at the remote systems that are used in hazardous environments and giving a lot of consideration to the types of electronics, sensors, and other equipment that are designed and have proven successful hopefully in the elevated thermal and radiation environments.

[Slide.]

DR. SEGREST: In taking a look at all of the technologies, the equipment that is available, we tried to look at setting up some evaluation criteria so that we could screen the systems available equipment for what makes the most sense to give further consideration to in our work on the repository.

When we look at various things with respect to licensing considerations, operational considerations, we have got to consider things like personnel safety, functionality within the type of environment it's in, reliability and maintainability.

We are always concerned about the reliability of nuclear systems. We are going to have to prove and justify their reliability in order to license the use of these systems.

Then with respect to maintainability, as we have indicated, a lot of this equipment will be operating in environments where you don't just go in and work on it. You've got to either remove it in order to work on it or find access to it. So we want things that can be maintained, that will be reliable to work within the drifts, but yet we can bring them out and relatively easily maintain them as necessary.

Proven technology is a preference. It is always easier when we are trying to license something to have some technology that is proven, that is available in the industry. It is also preferred from the engineering standpoint that we don't have to go out and develop and test new things that haven't been used before.

We also look at the variations in active and passive components to see what makes the most sense to use. Where there are passive components a lot of times they are preferable.

[Slide.]

DR. SEGREST: We do expect that some customization of the types of equipment controls may be required. We don't want a great deal of that. We know some will, but hopefully that can be minimized.

Looking at survivability within the environment.

We also have to look at the installation. This will be an operating facility. We don't want things that are extremely difficult or sensitive during the installation process if we can avoid it.

Of course we do have to operate on budgets in this program. So we certainly look at the installed cost, including the operational and management costs associated with the systems and equipment which we are designing for this.

[Slide.]

DR. SEGREST: We have taken a look at the various technologies, as I indicated before. You can see the list on the left are some of the various mobile communications technologies that we have looked at and evaluated.

We have talked to vendors. We have looked at the equipment, looked at things like the leaky feeder coax, the laser, the microwave, looked at where these things are applied, looked at how much they have been applied, what the state of the technology is so that we have things there are is some direct experience with.

The things you see on the right-hand side, the direct radio control is probably the most developed way of controlling vehicles and other things. That technology is in use in a lot of ways.

The leaky feeder coaxial cable is fairly simple. It is similar to the coax you might see run into your televisions, running in from the cable network. It is a little bit different in that the cable you would see on your television probably has a woven outer metallic shield in there. This is a little bit different because you want the signal to actually leak through it.

I will let you take a look at it. When you look at it, the thing you will notice, and this the thing that we have noticed too, is that the materials may very well not be suited to an environment such as your oven with that kind of temperature over a long period. But there are things that can be done perhaps as far as the materials that this is constructed out of to make it reasonable.

This type of technology is used in mining applications. There are other applications where it is used. Except for the material composition for the coax, it should be reasonable.

The slotted microwave is commonly used in elevators and in mass transit systems such as metro systems. It amounts to a tube. The microwave signal is sent down the tube and there is a slot within the tube where an antenna runs down the tube. The signal is contained there. So you don't have to have nearly as many transmitters. It is very effective. It is commonly used, as I say, in elevators, metro systems, and things of that nature. It may be in some of the little rail systems connected the concourses with the main terminal in airports. So that is another one we are considering.

The leaky feeder. We are concerned about the temperature applications. The slotted microwave would not be a temperature problem but the cost of the slotted microwave is maybe 20 or 25 percent higher to install.

Those are the things we are looking at.

[Slide.]

DR. SEGREST: Looking at providing power to the mobile vehicles, there are several considerations there. Looking at electrical third rails, trolley wire, cable reels. The cable reels we didn't particular like with the distance. Batteries, conductor bars, and so forth.

Since I had to have an example for the mobile control, I took a look at something like a conductor bar. It's very simple. There are various types of them. You can just about buy them at the hardware store. They are fairly simple. There should not be any kind of a maintenance problem. We have looked at those type of things. There are numerous designs of that available.

Our leading candidates for the further evaluation. We have got the conductor bar and the battery. Either one of those could be suitable, and there are probably some cost tradeoffs, and as we get further into our work we will begin to make some decisions there.

[Slide.]

DR. SEGREST: To take a look at just how this would work in the repository, we have got a simple diagram here. This is one layout. There are numerous ways we could do it. We are very early in our design here, but this particular one assumes that all the controls would be at the surface. Probably in the waste handling building there would be an area that has the computer control consoles.

In this particular design the red link is the fiberoptic link within the repository. This one uses radio control with the radio control equipment shown at various locations. Of course you would use your direct fiberoptic or hardwired controls to control things like the doors and the switches, and then you would use the radio equipment to actually control the vehicle movement and location.

Of course we also show on here that you can have some video equipment to aid the operator. Video cameras are fairly common in use. They are actually installed in reactor buildings where there is radiation so that you can monitor things going on inside those buildings even when access is not permitted.

[Slide.]

DR. SEGREST: The results of the recent design effort. We have some preliminary conclusions. Everything is pretty preliminary at this state. As I indicated, we are very early.

Where the temperature is below 50 degrees C, which is in the emplacement operations where we are moving the waste packages down to the emplacement drift and putting them into the emplacement drift the technology is available. We are concerned about how we will apply it and what we will use, but there is plenty of technology available to select from. The technology is there for the control, the communication, the command, and power; as far as the locomotion, the various mobility, the actuators, and sensors we need within the doors, within the switches, and so forth, the technology is there.

The key areas that we are going to be working on. The underground mobile communications. Even though the technology is there, we do have some questions. We have some concerns that we need to have answered as we make our selection.

The mobile power. We do have some choices and we need to do some design studies to try to select the appropriate power.

Then we have got to make sure that we have integrated the systems all together as far as the various things that have to be controlled and operated and how they work together within the repository operating scheme.

[Slide.]

DR. SEGREST: The area of the repository being the emplacement drifts, once the doors are closed and the temperature starts to rise, our greatest concern presently -- I didn't call these available technologies. I said they are promising technologies. Some work has been done but we have got to do a lot more review in our selection as far as the work that has been done, how conclusive it is, how appropriate it is.

Having a high temperature is one thing, but when you consider that a lot of the equipment you would like to survive the 100 and 150 years, not that we necessarily think that sensors, and so forth, would, but if we put in some kind of a cable such as the one I showed you, we would want something that would last a long duration. We would not want to have to go in and replace all that system in order to be able to retrieve waste or go in and replace and instrument.

So the elevated temperature applications are of concern. We are looking at some of the things with respect to the new heat-tolerant electronics, the various active and passive cooling systems that we could use for the motors on the gantry or things of this nature, and looking at advance heat insulation and heat rejection techniques.

So we do have a fair amount of evaluation work to do there to reach some decisions.

[Slide.]

DR. SEGREST: We then also have to consider what we are going to recover from off-normal conditions.

We have looked at various equipment failures that could occur. The ones that we have got here, the derailment, stuck isolation doors, loss of power, loss of communication, we have to consider what will happen if any of those things occur. If the gantry is moving down the emplacement drift carrying a waste package, what happens if we lose power, if we lose communication? What do we do about it? What is the effect of it? How do we recover from it? So we are taking a look at that, studying that as far as how to deal with it.

The systems that we deal with we can deal with with respect to redundancy and backup systems to ensure the safety and reliability.

After we have done all our design to ensure the safety and reliability, then we have got to assume that they are not that reliable; something fails, so we have to go in and recover from that event. So we would have to have plans, procedures, processes, whatever in place so that we can go in and remove a vehicle which may be stopped in an inaccessible area.

[Slide.]

DR. SEGREST: Some of the activities we have planned in FY97 are going to focus primarily on the remote handling concepts for the subsurface waste package handling equipment, communications and power supplies, and for the mobile remote power communication control systems within the elevated thermal environment.

So we are going to continue during FY97 to advance our understanding and hopefully head towards some actual selections of at least our preliminary design in this area.

That concludes that I have on that subject.

DR. CORDING: All right. We have time for questions.

John Cantlon.

DR. CANTLON: I take it from your drawings there that you produced that it would be the intent as soon as a drift is filled or indeed even as individual containers are put in the radiation doors will be closed, so that except when you are loading or unloading in a drift the radiation doors will be closed.

DR. SEGREST: Yes.

DR. CANTLON: Is the design such that ventilation continues?

DR. SEGREST: As long as we are emplacing in a drift it will be fully ventilated. Once we stop the emplacement in that drift when it's full, then it is no longer necessary to have full ventilation. There will probably be I guess what we refer to as some ventilation leakage, or whatever. So it's not a sealed door.

DR. CANTLON: What are the negatives? Is it a matter of possible safety leakage into the ventilation system, or are you actually trying to speed up the heating? Why don't you maintain ventilation so that you don't get drift to drift heating?

DR. SEGREST: With a large number of drifts in service and actually loaded with emplaced waste the requirements for the airflow would be rather large. It could get rather significant as far as the expense of having the ventilation equipment and operating that ventilation equipment over long periods of time.

DR. CANTLON: But you will have enough energy to get a kind of thermal drive in the ventilation system, won't you?

DR. SEGREST: Perhaps some. I don't know how much.

DR. CANTLON: What I am asking is, are you going to close it off so you don't even get the non-driven ventilation taking place? In other words, you can hold the heat down until you get a sizable portion filled off and you close off a whole section.

DR. SEGREST: There will be some circulation through there but fairly minimal. I haven't reviewed the analysis on the ventilation system to give you a real definitive answer on that.

DR. CANTLON: In the remote operating systems is there a mechanical backup for all of them? Are you visualizing every remote operating system will have a mechanical backup?

DR. SEGREST: It's a little bit early. We haven't done that yet. We are looking at redundancy, we are looking at ways to recover, but we are very early on our design on this. So we haven't necessarily put in mechanical backups.

DR. CANTLON: Being a gadget negative person myself, I guess I am much more comfortable if there is a handle.

DR. SEGREST: There would certainly be backups on things like the control doors, on the switches. There would be some things there. As far as having a mechanical backup, if an operator had to get access to it within a drift, that might be rather difficult. It's the the type of thing we are spending a lot of time evaluating and we are getting ready to make some decisions, but it's a little early.

DR. CANTLON: Murphy's law: if it can happen, it will.

DR. SEGREST: Yes.

DR. CORDING: Going back briefly to that item on the ventilation, are you at present not going to consider a long-term ventilation option or is the program not going to consider that?

DR. SEGREST: The assumed operating configuration at the present time -- of course the ventilation system operates. It's there. It's available for the 100 to 150 years, however longer. The assumption right now is that once we have completed loading in a drift we go ahead and close the doors and then there is some small amount of ventilation. That is where we are headed at the present time.

There is some work being done, I guess by PA and Science, with respect to maybe we want to continue the ventilation longer because of some advantages it may gain, but even though that is being considered we are not designing for that at the moment. That would be a significant increase in the capital cost for the ventilation system, and so forth.

DR. CORDING: Is it something you think could be accommodated if necessary?

DR. SEGREST: Certainly.

DR. CORDING: Don Langmuir.

DR. LANGMUIR: Alden, you have described a number of options that are being considered -- this is overheads 14 and 15 -- for mobile vehicle power technologies. Among them I see a number of bare metals exposed for long periods of time. These would include, if I am right, the electrical third rail, the trolley wire, the conductor bar.

DR. SEGREST: Yes.

DR. LANGMUIR: I could see how those if they are being used repeatedly and frequently could stay clean, but in 100 percent humidity and 200 degrees celsius, or whatever it is going to be, I expect to see corrosion products on the surfaces of these conductor materials. For example, the copper is likely to have copper oxide at 200 and copper carbonate on it below 100.

If you are depending upon direct contact for conductance to a vehicle, aren't you going to have some problems with these metals if they are left for decades unused and then all of a sudden you have to use them for retrieval and they are coated with some sort of a nonconducting secondary product?

DR. SEGREST: In order to use the third rail and so forth we would have to have some satisfactory method of cleaning it before we went in, and that could be done with some remote operation as well. We would either use that or we may actually be leaning toward the batter power. The expense of installing the third rail or the electrical conductor bar, even though relative, they are not expensive, but when you consider that they are installed to use them and then 20 or 30 years later before you want to use them again, then it may not be justifiable. So those things are being considered, yes, sir.

DR. LANGMUIR: What kind of batteries are happy at 200 degrees celsius with liquid electrolytes?

DR. SEGREST: That is a good question. I can't answer that for you other than to say that we are reviewing the technologies of what is available. We also have to consider the amount of time that the vehicle would be in the drift at that temperature. We also have the option of cooling the drift. If we are actually moving a package out for some reason, then we would cool that drift back down to in the range of 50 degrees C.

When we look at our performance confirmation activities and some of the things that we will need to do there, we will probably be sending some kind of -- I don't really want to refer to it as a vehicle; it may be -- but we will send some kind of a device into the drift without reducing the temperature perhaps to take some readings or maybe remotely replace an instrument or something of this nature.

We are considering the technology and we will have to consider how much time it has to spend in the drift and see what cooling or alternative things we can come up with.

DR. SNELL: A comment to supplement what Alden is saying. I think one of the things we are going to have to do in connection with the design is develop a -- first of all, we will look at reliability, availability, maintainability, and inspectability, for that matter. We are going to have to develop an operating and maintenance strategy and an operating and maintenance plan for the facility. You do this conventionally with lots of facilities. For this one it takes on some interesting implications because of the long life.

Don, the kind of question you are asking is a question that has to be asked and answered, because we are looking at a facility that is going to remain accessible for 100 years or more. So questions about what condition are the materials in on systems that we have to use and how we are going to deal with that I think need to be answered well before we ever get to the point of constructing and operating this place.

The question is a good one and we will have to answer that and many like it and commit those to writing. I think we will have to make those decisions as we go forward. As Alden says, we are just getting into some of those considerations now, but we will be addressing them in a comprehensive way, I would say.

DR. CORDING: We have a question from Jeff Wong.

DR. WONG: I recognize that this is only a preliminary design, but I was looking at the picture and just kind of wondered. It looks like the gantry is behind the door and therefore in the hostile environment. How is that you are going to service that gantry if it needs to be serviced?

DR. SEGREST: That gantry would not remain in that drift. That gantry would be put in the drift while that drift is being filled, and then that gantry can be removed from the drift and taken to the next drift and used there. So the gantry will move from drift to drift. So it will not stay inside. It can be removed.

DR. CORDING: Carl Di Bella.

DR. DI BELLA: Leaving the temperature and radiation considerations aside for the moment and thinking only about emplacement, what is the closest existing application you have for this remote emplacement with a similar degree of complexity? You are picking up and moving and precisely placing packages of different sizes and perhaps tying them down. What have you found so far in your screening studies that is close to that?

DR. SEGREST: I can't give you a good direct answer to that.

Dan, do you know which ones they were looking at?

He was shaking his head. So he may not either.

DR. McKENZIE: This is Dan McKenzie with the M&O. I don't believe there are any direct analogies. There is certainly a lot of precedent for moving loads like this and moving them around with great precision, but a repository is kind of a one-of-a-kind deal. Everything we do is going to be an adaptation of existing technology, and that is what we are looking at here.

DR. CORDING: John Cantlon.

DR. CANTLON: When you are working with the management cost estimates, are you working with any kind of assumed frequency of out-of-normal events, or are you just setting those aside?

DR. SEGREST: The primary thing we are working with right now as far as the cost estimates, we have started looking at the procurement and installation cost. We have started thinking about the survivability, reliability and maintainability. The first thing we are looking at, and we really haven't gone very far beyond it, is just the installation and procurement cost of the various systems.

DR. CANTLON: So eventually as you try to get realistic numbers you are going to have some kind of a prediction of what types of out-of-normal events you are going to encounter and try to plug those into what-if costs?

DR. SEGREST: Yes. That is a significant part of it. We will probably start on some of that this fiscal year.

DR. CORDING: Woody Chu.

DR. CHU: Would those costs then be part of the cost estimate that will be part of the viability assessment?

DR. SEGREST: Those costs are probably noise within the system relative to some of the other things we are considering on waste package. We will certainly start looking at putting in the various costs for the remote systems, for the control systems, and the costs do include the capital cost as well as the operating cost over the period. So, yes, they will be included.

DR. CORDING: Dan Metlay.

DR. METLAY: Focusing on the hardware, have you looked at some of the recent work that has been done on the issues associated with operating high reliability organizations?

DR. SEGREST: High reliability organizations?

DR. METLAY: There has been some work on things like organizational requirements for things like nuclear aircraft carriers, for maintaining the safety of the nuclear weapons systems. There is a whole set of issues that deal with how you organize high reliability organizations, and presumably you are interested in that kind of a question for a repository.

DR. SEGREST: We will be; I guess we are now; but it hasn't gotten high enough on our screen right now. With looking at the overall repository operations, so much is laid out, organizations to see how many people it will take to operate such a facility, but as far as getting into the details of the organization, it is a little bit earlier for what we are doing.

DR. CORDING: Bill Barnard.

DR. BARNARD: Alden, you mentioned that you have talked to a lot of people who have had some experience with different components of the system. Have you ever gotten together in sort of an advisory group or brainstorming group where all these people that work with components have gotten together and you have presented this to them and said, well, how is it all going to work when you put it together, or is it going to work?

DR. SEGREST: We haven't done that yet, no, sir. That is something that would be wise to do when we start trying to integrate the system to make sure how it will operate with the various components, the various types of control. It would be most wise to do when we get to that stage, yes.

DR. CORDING: All right. I think we are ready to proceed to the next discussion. This part is on drift stability and maintenance, long-term maintenance. Alden will also be presenting this one.

[Slide.]

DR. SEGREST: This is a little overview of what I plan to talk about: The description of the drift stability issue and long-term maintenance of drifts, the impacts of that drift stability on the repository design, and the various activities we have performed recently to resolve the issue.

[Slide.]

DR. SEGREST: Drift stability and maintenance is a very significant issue in our design. We will be spending a great deal of time on it. In this fiscal year we have been spending a fair amount of time on it. The work we have done on it is rather enlightening. It has caused us to change some of the direction we are heading in what some of you may have seen in the advanced conceptual design report.

The issue is significant for a number of reasons. The construction material that we use for the ground control has got to be compatible with post-closure performance. That has become rather significant in itself.

We had a meeting recently with our consulting board. We talked some about steel; we talked some about concrete; and we started hearing negatives on both. There are problems with the material we use, so we are going to have to try to select an appropriate material. Post-closure performance is the issue that is driving that material selection as much as anything.

We have also got to consider performance confirmation. That factors in when we begin to install the ground support as we are cutting the drifts, and later on with the performance confirmation work that may have to be done throughout the life of the repository. Then we want the ground support to be compatible with the construction method. If we appropriately design the ground support and the TBM to operate together, then it significantly improves production and reduces over cost for construction of the repository.

The time period we are looking at is 150 years. The drifts are relatively inaccessible. So we want the ground support to be there for 150 years with a minimum amount of inspection and maintenance.

Then we have got the heat and radiation considerations, which make that access for maintenance extremely difficult. It is not impossible, but it does make it difficult, and we try to deal with that in our ground control design as well.

[Slide.]

DR. SEGREST: The drift stability work affects the ground support system; it affects the actual layout of the repository itself as far as how we lay out the drifts and how we lay out the access tunnels.

Retrievability is an issue which we cannot escape from and that we keep having to consider in all of this work, and it has its impact on how we do things.

[Slide.]

DR. SEGREST: As I indicated, the post-closure performance of the repository affects our selection of ground support. We have looked at some things such as concrete.

There has been a recommendation. We are trying to put in our design now of using precast concrete segments. In doing that, the first consideration that we had to look at before we could even think about doing that is the impact on the performance assessment. Post-closure performance has a significant impact on the pH which has significant impact on the transport of the radionuclides. Our performance assessment people are working closely with us on that issue.

There is a requirement for data collection. That requirement is not clearly defined at the present time. Right now in the ESF they map continuously behind the TBM as it goes down. The system is designed so they can do that.

We put a lot of effort in the design of that to make sure they were able to see as much of the ground as possible. We need to reach some decisions and conclusions on how much ground we have to look at in the emplacement drifts because that will impact our ability to install the type of ground control we are looking at.

The precast segments should go in right behind the machine where you would never get to look at the ground. If we go with a two-pass system, such as a cast-in-place concrete, then the mapping would be available, but that would be probably a higher cost system.

I missed the last bullet concerning the long operational life. There has been a lot said about that. It's a significant consideration in our drift stability work.

[Slide.]

DR. SEGREST: In looking at the repository layout, the orientation and location of the repository is a consideration. We look at trying to locate the drifts such that they are perpendicular to the fractures that we see in the rock. A lot of the ESF work where they have looked at the fractures tells us we may have to make some adjustments to the direction the drifts go, but that is a consideration we have.

The size and the shape of the drifts. The drift for emplacement is pretty well decided since that will be excavated by a TBM. It will be round. We are also looking at the size of the ground support for the turn-outs to each of the drifts.

The lengths of the emplacement drifts are a consideration. You have already seen some diagrams of the more recent repository layout where instead of having the drift access from one end only we have the drift access from both ends so that it is essentially half as long.

[Slide.]

DR. SEGREST: A reliable ground support system is necessary to have a reasonable method of retrieval. We need to have a ground support that will have some level of confidence will be in place for 150 years. We have to consider that we will need to go in for some kind of maintenance or to repair something that may happen in there. Who knows what, but something may happen. So we have to be prepared to deal with that.

We have to consider the off-normal conditions.

With some types of ground support those off-normal conditions are likely to be lesser in severity than in others. So that is a substantial consideration.

[Slide.]

DR. SEGREST: The recent work that we have done in this area.

I think you all are aware of our Repository Board of Consultants that has been assisting us. This is essentially the same board that worked on the ESF and now they have refocused their efforts toward the repository. We have had some meetings to them and presented to them what we are doing and gotten some very valuable feedback from them.

They have given us some things to think about and consider. We pretty much agree with most of what they say.

Their recommendations are to provide a single and robust ground support design suitable for all expected rock conditions. In the ESF we have a menu of ground support designs to select from. The constructor selects from that menu based on the conditions in the tunnel. With the emplacement drifts we are headed toward a single ground support design which will be installed all along the drift so that there would not be a menu to select from as the TBM moves along the drift. It will be the same support all the way.

We are looking for some economy in the efficiency of the construction operations by making the system compatible with the TBM so the TBM is designed for that particular ground support and for the particular repository design as we lay out. That will simplify the construction and also make it such that the construction is faster, which affects the cost of the construction.

Also, we are looking at the available information from the ESF. A lot of information is being gained on the rock structure geology. A lot of information is being gained from the ESF. We are factoring all of that information into the work that we are doing on the ground support design for the repository.

The initial ground support design for the ESF was done using borehole data. A lot of work was done there. Some of the designs were conservative, perhaps more so than necessary, but now that we have the actual data from the ESF that has been gathered in the mapping and scan line data and so forth, we know more about what to expect in the emplacement drifts so the design there will be a bit more precise.

[Slide.]

DR. SEGREST: This diagram, no matter how hard we try, doesn't quite show what it was supposed to, the drift itself. This would be a precast concrete liner in segments. The invert section of it shows the rails for movement of the gantry. It shows pedestals spaced intermittently along the drift for the waste package placement.

A few things you will notice here. There is no provision obvious in here for us to go back and look at the drift wall behind that concrete after the ground support is in place. That is something that we have got to consider. That is one of the questions we have in our design.

The segment lines don't show up on here, but it would be installed in concrete segments. We would make a determination there with respect to what would be a reasonable size to handle.

[Slide.]

DR. SEGREST: Other recent activities or developments.

As I have mentioned, we have reduced the length of the emplacement drift by making them accessible from both ends.

Develop a gantry system -- you have seen a lot of that in various diagrams in the past two days -- for moving waste packages in or out of the drifts.

We have also considered that we may need to get into a drift and maintain it, and the best way to do that is to remove the waste packages from it. So the design now includes some parking drifts, as they are referred to, where we could actually unload an active emplacement drift; we can unload the waste package from that, move it to this parking drift such that we can go in and perform some kind of maintenance or repair operation on that emplacement drift.

[Slide.]

DR. SEGREST: The layout, which you have also seen a few times. Some of these slides may be getting old. We see one, we like it, and we pass it around. On this one you see some parking drifts specifically for the purpose of allowing maintenance. Not show here, but there are also some inspection drifts that are part of the design. You have seen enough of that one, so I won't leave it up too long.

[Slide.]

DR. SEGREST: Some more recent activities to resolve the issue we are working.

Some study was initiated a few months ago to study the use of cementitious materials within the emplacement drifts.

That work is progressing. We are expecting to see a preliminary report the first quarter of FY97, and we are expecting to make a decision as far as the drift design for viability assessment and material usage. We expect that decision to be in the second quarter of FY97. We are trying by March of 1997 to provide a fairly complete inventory of the types of materials we expect to use for the performance assessment work.

We are also continuing to address the various performance confirmation issues, such as the drift wall mapping which has to be dealt with, and we are working with the licensing and site groups to try to reach some conclusion on that as to how we want to approach that.

DR. CORDING: Thank you very much, Alden.

A question from John Cantlon.

DR. CANTLON: In your last item where you are trying to get at the mapping of the drift walls, it would seem to me there is an opportunity here to do a little remote geology by having a TV camera right behind the cutting face as the precast concrete things are being slid up, producing essentially a continuous photographic film of what that raw surface is. The difficulty, of course, is it isn't a wash surface, but maybe that could be handled with air or something like that.

It does seem to me that that would permit you to move very rapidly and you would have an absolute geological record long before you are emplacing. That obviously isn't as good as a geologist licking the rock as they are inclined to do, but it's the next best thing.

DR. SEGREST: That's a consideration. The big question is how much mapping do we need to do. We will currently have a great deal of information on the entire perimeter and there will be some inspection drifts. Is that enough? It may be.

DR. CANTLON: You know already, though, from operating in the ESF the troubled ground isn't always related to known faults, and so on. So one would expect a fair amount of heterogeneity in there and it would be very good for confirming with NRC and so on that you have got an actual record of the total geology through the system, and once you set it up and operate it you've got a proven record of what you have been over. The question is, can you design a system that is robust enough to operate a TV unit behind the cutting face that will generate a record for you?

DR. SEGREST: I would think that is a possibility. We haven't worked with vendors on doing that yet. At such time as we get ready to do this we will be working with the TBM vendors.

DR. CANTLON: You clearly need the geologist with you.

DR. SEGREST: This is an issue that we are working primarily with the geologists and the licensing staff, because it is not an engineering decision as to whether to do it. If they tell us to do it, it becomes our decision as to how.

DR. CANTLON: Have you given any thought to looking at some of the new carbon composite concretes, carbon fiber composite concretes that have an enormous improvement in strength?

DR. SEGREST: From an engineering standpoint, the preference in the concrete is to select a standard concrete, some kind of a fairly standard design available from the handbook without having to develop something new. We would like something that has some proven use, some reliability. We would like to do that. We do have some flexibility if they are precast because they can be made outside so we don't have to worry about the drying and so forth occurring inside the repository. So there are some advantages there.

We have got to look at the high temperature concretes. A lot of your standard concretes when you get above 150 degrees Fahrenheit you have to start answering some more significant questions about how long they will last. So we are looking at the high temperature applications.

We are also looking at the lower pH concretes, which are more suitable for what we need from our PA standpoint.

Some of the other composites, if they answer the questions, we will indeed be trying to review.

DR. CANTLON: You have got a decade before you start loading and you have got 50 years of loading.

DR. SEGREST: Correct. Yes, sir.

DR. CANTLON: The point is you don't want to get frozen into obsolete technology, and it would seem to me it would be very nice to have somebody looking at some of these specialty concretes that have very much more strength, very much lighter, and now the question is, is the carbon fiber going to generate a problem? Obviously now the cost is prohibitive, but that is not necessarily true if you get a big flow of the material coming in.

DR. SEGREST: Using the fiber in the concrete is definitely being looked at and considered.

DR. CORDING: Fiber reinforced concrete has become a pretty standard product, wire fibers and things like that. The question is whether you need it or not. What you are really looking for in this concrete is not so much a lot of strength, particularly compressive strength, but something that will just stay there in contact with the rock for a long time.

DR. SEGREST: Chemistry is a big concern here.

DR. CORDING: I guess the point is there is almost no support system that you can come up with as a continuous support system with present technology that does not include substantial amounts of cement. If you are talking about putting in a concrete lining, either cast in place or precast, that is obvious. Also, if you started looking at continuous steel segments, for example, the backfill behind those is some sort of cement or grout, a large component of actual cement there.

Present technology for continuous supports, almost of them require significant amounts of cement, and I think that having to not use cements in the project is a major problem for being able to use standard technology.

DR. SEGREST: The way we have asked the question on cement is we have said we need to use cement; we need to use cementitious materials, concrete, in the repository emplacement drifts. So I go to the PA organization and I say, help me do it. Help me figure out a way to do it. There are certain types of concrete, certain additives, whatever we can use. So I ask them to try to help me reach some kind of a conclusion such that in engineering this we could use cementitious materials.

DR. CANTLON: It seems to me that the time that the high pH is going to give you a problem is out in the distant future, not during the construction, loading or retrievability period. That is why it would seem to me the smaller the mass of concrete you put in there the lower your high pH problem. That is why I am thinking getting these very thin, very much stronger concretes would be a way of getting TSPA numbers in which the high pH isn't a problem out there at 50,000 or 100,000 years.

DR. SEGREST: You have mentioned some of the most significant issues with using a liner of this nature. The lighter weight can be handled easier; a better chemistry from the post-closure standpoint. So those are indeed things that are significant issues to us and we need to look at.

DR. CORDING: Don Langmuir.

DR. LANGMUIR: On the same subject, Alden, why does the prestressed or precast concrete have to be 360? Without knowing more than I think I know, I would have thought 200 degrees circular might be sufficient and the invert then being crushed tuff. If you make a total tube, what are you gaining over making two-thirds of a tube? The invert of crushed tuff is the most stable material for millennia, because it is all around you in the rock. It provides a lot of buffering for any leakage from a waste package. You can also doctor it. You could lay a little bit of spent uranium on the top of the stuff next to the canister. You can do things with very cheaply and you don't have to pay for it; it's right there on the site.

Also, if the concrete uses tuff as the makeup material for the concrete, you have made it chemically more similar to the mountain and less vulnerable to alteration through time, because its chemistry won't be that different.

Also, the lime effect on pH is an early effect in concrete, as I understand it. It tends to go to calcium carbonate in the atmosphere and you are not likely to see the high pH's after a few decades unless you rupture the material and go internal in it where you haven't gotten the CO2 to react with the lime.

DR. SEGREST: We have done a lot of analysis as far as the types of stresses we would expect to see on the ground control, whether it's concrete, rock bolts, whatever we would use in there. So we have done a lot of analysis. We initially had some considerations about having the cylinder in there because of the hoop stresses and the side stresses from the thermal. From the stress analysis we have done it looks like having the concrete cylinder, steel ribs, whatever, is the most preferable way.

Some of our earlier work looked at putting in a shotcrete. When we got into some further looking at the 200 or 270 degrees, we looked into that further and that didn't quite fly with respect to all the stress analysis we had to do.

DR. LANGMUIR: One other minor thing. Looking at your diagram -- it's not your talk; it's an earlier one -- the very heavy packages are going to be sitting presumably on concrete pillars, little support.

DR. SEGREST: Yes, pedestals.

DR. LANGMUIR: There is a lot of literature out there on stress reactions, the effect of pressure on solid phases, increasing their solubility and their kinetics of dissolution. You are likely to create much more reactivity and degradability on those pillars because of the weight than any other concrete around in the tunnel. You might want to reconsider using concrete to carry that weight load at high temperatures and pressures. You have got a lot of pressure and you have got a high temperature and a lot of moisture. So there is a reactivity there.

DR. SEGREST: I know we have done a fair amount of evaluation with respect to the waste package itself as far how best to support it, but as far as doing the actual analysis of the pedestals, and so forth, I don't believe we have done any of that yet to speak of.

DR. LANGMUIR: I have visions of those as piles of sand where they used to be in 150 years and the thing sitting on the bottom of the tunnel.

DR. SEGREST: Yes. Now you are going to cause me to lose sleep with that same vision.

[Laughter.]

DR. CORDING: You made a comment that you wouldn't be able to look at the ground later through the lining. Did I catch that correctly? Is there a reason you want to look at the ground later?

DR. SEGREST: There may be from the performance confirmation standpoint. That is a question that we have on the table.

DR. CORDING: You mean actually view the rock?

DR. SEGREST: We are asking that question from the standpoint of performance confirmation: do they need to be able to go back and view that rock at any point after the emplacement drift is closed? If the answer to that is no, then it makes our engineering work a little bit simpler. If they do need to go back, we are going to have to somehow provide some windows in the concrete or some method.

DR. CORDING: It would seem that if you are trying to understand what the rock is doing you could look at it with how much strain or displacement is occurring; are there gaps behind the lining. Things that could be done with some sort of sensing. If you are concerned, for example, about gaps developing or present behind the lining, you can see some of that sort of thing with some sort of impact echo type of testing. You could get some information off of ground penetrating radar or things like that. My reaction would be it won't turn into a major issue.

DR. SEGREST: There is some work being done on the performance confirmation requirements and system studies and so forth being done with respect to determining what those are so that from an engineering standpoint we know what to design for. The question is somewhat open right now as far as how much rock they need to see.

DR. CORDING: The issue that you are dealing with, mapping as the TBM goes forward, is certainly one that seems to be more of a major issue. It would seem that whichever way you go on it it is something that you can resolve. There are ways of taking care of this with some sort of continuous lining, whether you had to delay it or whether you provide windows as you go forward, or whatever. It is an issue to be addressed but it seems like there is some way forward on this.

DR. SEGREST: There is certainly a way forward. We would like to have a good enough answer so that when we do our VA design, which we need to make a decision on this particular issue by March, we know what we would like the decision to be, but we have got some requirements that may come to us that we have to meet. If we have to be able to view the rock before the ground support is placed in position, then we either have to go to a two-pass system and then we may use a cast-in-place concrete, or we would have to come up with some suitable method to view the rock before we put in the precast segments. I am sure there is answer to either one.

DR. CORDING: With the two-pass system and then using cast-in-place concrete, of course you have an initial support requirement there, as you know. In driving the tunnel in a more favorable direction with respect to the fractures, in a smaller tunnel the support requirements should not be as major as they have been in portions of the repository main drift that has been driven. Perhaps rock bolt support is going to be adequate for most of that. Then you lay in your cast in place which in itself could be an efficient operation certainly.

It seems to me that the type of support systems you are looking at are the ones which are most desirable for ground support for very long periods of time. It seems to me that you are moving in the right direction on these support systems.

Don Langmuir.

DR. LANGMUIR: How long would these precast concrete segments be? What length would you envision them? You have got to move them around in there. So they can't be terribly long. You have got to make corners.

DR. SEGREST: I would have to guess at that.

Somebody in the back said this long.

DR. CORDING: One meter or 1.2 meters.

DR. SEGREST: That will all go hand in hand as the machine is designed to determine what the reasonable handling is.

DR. LANGMUIR: The only reason I ask the question is because if they are really long, they influence the hydrology that enters the drifts. If they are very short, they don't. But that may become a factor in your modeling and consideration of the hydrology entering drift sites.

DR. SEGREST: I can see you understand the complexity of what we are trying to deal with.

DR. CORDING: Thank you very much.

Are there any comments or questions from the audience at this point?

Richard Parizek.

DR. PARIZEK: On Don Langmuir's point whether or not these shields are part of the engineered barrier considerations, it could be a drip shield, for instance, or some way to kind of keep water out from hitting parts of the canister locations. If you have a gap on the outside of them, do you backfill that with concrete or do you put a permeable material in there? In which case you have a capillary barrier possibility.

There are lot of things you could do with this. The whole question is, is that in the thought process for engineered barriers?

To bring up the stress point that Don also raised about the pedestals, my question would go to the canister itself, whether or not that stress on the canister enhances the corrosion of the metals that are going to be used to house the waste. Not only the pedestal, but then the water contacts that might develop between the pedestal and the waste canisters. Drip shields enter into that discussion.

DR. SEGREST: Indeed I can see that you also have some understanding of the complexity of what we are dealing with. What seemed like almost no neverminds can become very significant issues. The pedestal/waste package interaction is a significant consideration.

From just a straight structural standpoint we will look at the ground control, just from a structural standpoint of supporting the ground. Then we have got to go in and we have got to consider all the thermal influences, because it is not just the heating in that drift; it's the heating from the side drifts and the additional stresses that we get on the sides of the tunnel where the stresses there are greater than the top and the bottom. So we get into those considerations.

Then we get into the hydrology, the effect of drying out. We are hoping to learn something with regard to what happens there in the heated drift test which is soon to be constructed. I think that is supposed to actually start by the end of FY97. We do have a section of concrete ground support being included with part of that where hopefully we will learn some things about how the concrete behaves and interacts with hydrology, and so forth.

Without really having a direct answer to your question, we are considering those type of things in the work we are doing, and that is what makes it so complicated.

DR. CORDING: Are you looking at the possibility of some sort of layering of the lining in such a way that it has a more permeable zone or open zone that might serve as some sort of capillary barrier or a way of shedding water around the lining?

DR. SEGREST: I think before we start looking at too much of that we are really going to be interested in what comes out of the thermal testing as far as the hydrology there, what the impacts are of the temperature, and so forth. So we are still in a learning mode as far as how that may affect us.

DR. CORDING: The precast concrete segments that go in, are you at this point thinking about expanding the expanded segments behind the machine instead of grout? There are two alternatives. One is to expand the segments out to the ground to gain most of the contact. The other is just to put in a ring and then the gap between the ring and the ground is filled with cement, mortar or grout.

DR. SEGREST: Dan, help me out. Well, Kal is going to help me out. Okay.

DR. BHATTACHARYYA: I am Kal Bhattacharyya. I am closer to the microphone, so I will give it a try. At this moment I believe the idea is not to grout it, Dr. Cording, but make it so that it takes a lot of initial displacement, so it is more forgiving to the displacement. We will fill in behind it with maybe pea gravel or something like that if there are any voids. Otherwise it will just be free floating.

Does that answer your question?

DR. CORDING: You say you would expand it into contact with the ground?

DR. BHATTACHARYYA: That's correct.

DR. CORDING: As it comes out behind the shield you have to push it out to get it to the ground.

DR. BHATTACHARYYA: That's correct.

DR. SEGREST: Thank you, Kal.

DR. CORDING: Thank you very much, Alden.

We will now continue with the presentations on the repository operations and design. The presentation we have is on thermal management strategy from Dick Snell. This is an obviously important part of the overall design and an area requiring a lot of interaction with the performance assessment and the testing programs that are part of the scientific studies.

DR. SNELL: Good morning. As you just mentioned, Ed, the subject is thermal management strategy.

[Slide.]

DR. SNELL: I would like to talk a little bit about several aspects of the thermal management strategy.

Kind of an overall discussion, first of all.

Some conversation about thermal management goals.

A little bit of information on the testing that we are currently engaged in, testing that we expect, and some that has been done in the past.

Some design and operational considerations associated with the thermal management approach that we use.

Issues. There are several. I will highlight just one for the time being.

And then a brief summary of where we are.

[Slide.]

DR. SNELL: First of all, in talking about thermal management, in present terminology we are talking about the quantity of waste that we are going to put in per acre in the repository and generally in metric tons of uranium per acres.

One of the objectives is to create a thermal loading or emplace a thermal loading which will help us create a relatively dry environment in the emplacement drifts for as long a period of time as we can. The dry environment is a beneficial situation from a corrosion standpoint on the waste package materials, the materials of construction. The longer we can get the heat from the waste packages to move moisture away from the drift and keep it away from the drift the better off we will be from a performance standpoint.

[Slide.]

DR. SNELL: The thermal loading consideration is a comprehensive one. As I think you have already concluded and commented at times, it tends to affect almost every aspect of the repository that we are dealing with.

It certainly has a bearing on waste package design. It has a bearing on the subsurface design. We will get into that a little bit more.

It potentially has an impact on surface design, because when we talk about thermal loading and thermal management, we may be talking about situations where we want to do a mix and match on the waste coming into the repository, and that may mean we need to have some facilities on the surface to allow us to do that mix and match. Temporary storage of incoming materials, if you will.

It may have a bearing on site characterization. It has had, really, because we are talking about information that we need from the site characterization program, the influence of thermal loading on the rock, on the mountain, and a great deal of information that has already been accumulated on the subject. There is more to come. As we go forward we may find some aspect in which we need better definition or more thorough information, and we will have to work that with the science and PA people. That is the performance assessment piece.

As far as implementation, we have done a number of studies of various kinds in science and PA and engineering to suggest to us some initial recommendations for thermal management requirements.

This next line says we have developed a thermal loading strategy. I will have to say that that is tentative or certainly in an infancy stage at this point. As an example, you have all heard quite a bit of discussion about the infiltration flux rates we are talking about. That is fairly recent information. Changes of that sort of characteristic can obviously drive the thermal management option for us in major ways. So we have a situation which appears to be a good reference case right now for thermal loading. We are going to have to stay with this for a while in order to come up with something that we ultimately have confidence in for the long term.

We are progressing with some design and design evaluation work.

And we have an integrated thermal testing program that is already under way. You have heard some of that already. I will revisit a little bit of that in a very general way.

[Slide.]

DR. SNELL: From a strategy standpoint and from a basis for us, we are talking about the 70,000 metric tons capacity for the repository which comes out of the statute on the nuclear waste policy program.

We have previously talked about a reference thermal loading range of from 80 to 100 metric tons per acre. At about 83 tons per acre, roughly in that number, we find that we can get the 70,000 metric tons into the current footprint in a relatively straightforward fashion. In fact, with some of the improvement they have talked about here in this meeting, the repository underground design is a little more efficient than it has been in some earlier versions you have seen. So we actually have a little bit of spare capacity in that current footprint at that 80 or 83 MTU figure.

We have got to meet the performance objectives. That is first and foremost the driver on what we do with thermal management. We have got to have something that satisfies the waste isolation strategy, something that is consistent from a performance assessment standpoint, consistent with the scientific information that we have been assembling.

We want to retain some flexibility, because alternative thermal loadings may prove in the long run to hold some real merit for us. The ranges that have been considered heretofore have been from as low as 20 metric tons per acre up to as high as about 100.

[Slide.]

DR. SNELL: In looking at what we do with thermal goals and the assumptions that we make and the requirements that we set, some of the goals were initially defined in the site characterization program. They have been updated in some recent studies.

We have some methods so that assumptions that we choose to make in the design and use as an ongoing basis we can document in a controlled design assumptions document, a CDA, which is a part of our answering documentation.

Those things that are statutory requirements or mandated to us by the program go into the requirements documents. Those are must do, must meet kinds of things. Again, that documentation is controlled and remains with us throughout the life of the project.

[Slide.]

DR. SNELL: Let's talk about some of the thermal goals generally that we have been looking at. You have heard some of these before but I will revisit them a little bit.

Cladding temperature limit. We are talking about something less than 350 degrees C as a working number so far. It appears that the integrity of the cladding and the fuels that are going to be disposed of has some merit for us in terms of the waste isolation, the period during which we can expect to have proper waste isolation. We don't want to give away any potential benefits in terms of waste isolation, so we want to preserve the cladding as best we can. The information we have suggests that if we maintain temperatures of less than 350 we get the most effective benefit from it.

There is a related goal noted there that has to do with backfill and looking for reasonably good conductivity from backfill. The reason is that if you put anything around the outside of the waste package it is going to tend to drive temperatures higher inside the package. So if you want to maintain 350 on the cladding and you want to blanket the package with some kind of backfill, you need to do it in such a way that you don't make too good an insulator out of the backfill and cause that centerline temperature to go higher. It's a combination.

The drift wall temperature less than 200 degrees C. There has been a lot of discussion about that heretofore. It's a fairly conservative number, and in my experience it tends to be, I would say, a high side number. I know in other design applications, in my experience anyway, if you get up to 200 C or something close to 400 degrees F, you are getting into a range where you can begin to question the concrete's ability to maintain its integrity. It is kind of a high side bounding number that we are using right now.

[Slide.]

DR. SNELL: If you look at some of the geochemistry goals that we are working with design bases right now, at one time it looked as though a temperature limit at the interfaces on the TSw2 and TSw3 strata on the site would be a good thing to do.

The comment here says "no technical basis found." That is probably a bit strong, but I think the suggestion now is that there is not a sufficiently strong reason for holding that 115 degrees C, to hold that as a bounding value. So we are not at the moment using that on a continuing basis.

Heretofore we have looked at 115 degrees C limit in Calico Hills for protection of zeolites. We have modified that or are proposing to modify it and go to a lower temperature limit, 90 degrees C, at a depth of 170 meters below the repository horizon. There is a little bit of explanation that goes with this, and I will try and keep it fairly simple.

First of all, as with cladding on the fuel, the zeolites have a potential benefit from a waste isolation standpoint. We want to preserve the zeolites to the maximum extent that we can.

The mapping underneath the repository horizon right now is fairly good, but there are three or four different models that are being prepared and worked on to characterize the zeolite patterns underneath the repository. Those models are not in precise agreement yet, which is one of the reasons we are doing several.

The suggestion is that the zeolites closest approach to the underside of the repository working horizon perhaps is on the order of 125 to 150 meters, somewhere in that range. That is suggested by at least one of the models they are working with. That tends to be down in the southwestern portion of the repository footprint. As you move north and as you move to the east zeolites are still present but they exist at levels much further below the repository horizon, distances of 170 or actually more than that, 190 or more meters below the repository.

Moreover, some of the models suggested zeolites may not be present over the entire repository footprint. There is a suggestion in some modeling that again in the south and the west the zeolites either are thinning or are nonexistent for portions of the footprint.

However, the potential benefit is there. The recent information on the high flux rate suggests that the benefits of the zeolites may not be as great as had been previously anticipated. Nonetheless there is still some benefit. We don't want to give it away.

What we have decided here is we will use this 90 degrees C at 170 meters below the repository as a working assumption. What that does for us is that we think based on the most conservative information on when the zeolites are affected chemically by temperature 90 degrees is a very conservative number. The likelihood is that a higher number would be tolerable without any irreversible changes.

Secondly, the depth, using 170 as an average and looking at the mapping we have, suggests that about 10 or 15 percent of the area under the footprint might -- I may might -- be impacted to some extent by that sort of a design goal. Our expectation is that probably that is again conservative. I think when we get better data on the temperature impact on the zeolites and get a little bit better correlation on the mapping we will find that we probably affect a very, very small percentage if any of the zeolites underneath. We don't want to fiddle with the mountain and its beneficial aspects.

[Slide.]

DR. SNELL: Let's talk a little bit about testing.

Obviously we are doing a lot of thermal, mechanical, hydrological properties testing. Lab tests also on some of the processes that we think are going to play into this thermal management and the actual installation.

We are doing a good deal of work in corrosion testing, accelerated tests on materials, galvanic protection potentials and things related.

And we are doing some in situ coupled process tests, which are just beginning to get started. Some of those are accelerated tests, by the way.

[Slide.]

DR. SNELL: Looking at thermal testing program, there is nothing, I don't think, that is surprising to you here, but I would like to comment on a couple aspects of it.

The old climax test you are familiar with. Different rock. It's granite, but some comparative aspects. G-tunnel, similar welded tuff. Not precisely this one but similar, and again some reasonable correlation.

Some laboratory and corrosion testing has been ongoing for a long time. The intent here is to show that we have shown a break here around the current time frame, but it is ongoing. The intent with that dotted line on the right is to indicate our expectation is it is going to be ongoing for a longer period of time. Things change. We will have new needs. We will get some surprises undoubtedly, and we expect to continue that testing.

Drift scale test. We are just getting started. You have heard about some of that already. The shakedown test, the initial test has begun. It was started in August. The drift scale test, a bit larger one, the full size is scheduled to start late in 1997.

Large block test is anticipated to be performed. That was discussed earlier.

Single heater test I just mention.

First repository drifts under current scheduling in the program plan would occur in 2010. Recognizing that we have got a performance confirmation program to put in place here and looking at that kind of timing, the expectation, at least on my part, would be that some kind of testing is probably going to be with us for a long, long time to come, much of it confirmatory in nature, of course.

[Slide.]

DR. SNELL: In connection with some of the corrosion testing, just a little bit of a quick look here. This is a picture taken up at Lawrence Livermore Laboratory where they have a number of the corrosion tanks. I think some of you have been in that facility. Some tanks are installed and samples under test already. There is more tankage that was recently procured. Some of just gone out for procurement of additional tankage in September, I believe, in order to begin testing on more samples.

They are looking at quite a wide range of materials. I think the number of samples they have got in this program is like 11,000 or more samples when you look at the various materials, the various types of tests and the various durations they are looking at.

They are using J-13. J-13 is a well out at the Nevada test site. The reference there is to the water chemistry in J-13. They are using a concentrated J-13 environment as kind of a typical or for instance expectation for the repository area.

They are also looking at some acidic and alkaline environments that have been created for the testing purposes, bounding kinds of test conditions.

This work includes some galvanic cathodic protection tests, and you heard some discussion about the potential benefits in the way they do the waste package construction and the possible benefits of galvanic action that we might get.

As I mentioned, some of the testing has just begun. September is what we are showing.

[Slide.]

DR. SNELL: A quick picture here on the single heater test. This is in the first section of the thermal test alcove. There is a little picture on the following chart which will position this for you better. I'm not sure I have got the orientation right, but this in a little offshoot from the thermal alcove test.

It just started in August. About 353 instrument holes, approximately something over 600 channels of instrumentation on that test.

[Slide.]

DR. SNELL: I think you have seen some of this. This J-hook arrangement shows up on some of the drawings on a little bit smaller scale, but this is the one that you see on the large ESF maps. It is located just around the turn from the north ramp into the north/south main drift.

They are looking at coupled testing. It's a full diameter drift. The short end there on the J-hook is the area where the full-scale drift testing is going to occur. Presently the access drift, the long leg coming off the main drift has been excavated. The shakedown or the initial heater test is off to the right there, right near the main drift, the one that is referred to as the thermo-mechanical alcove.

Construction is active now in the section going across to the full-scale drift. Design is being completed on the thermal test section of the drift, the full-scale drift test piece. That is the one that will start late in 1997. It's quite a comprehensive test in terms of instrumentation, some over 6500 channels of instrumentation.

[Slide.]

DR. SNELL: Let's talk about some of the

operational aspects that are associated with the thermal management.

Emplacement sequent of the waste packages or waste assemblies is one part of the method you can use in thermal management. By sequencing the waste packages or sequencing the assemblies, you can control heat outputs using a selective basis on how you put them in.

There are some ratios here indicated based on several times delta factor, if you will, on heat release. I don't have the supporting information here, but it is substantial and it looks like there is good merit for us in considering these things. That is what would have a bearing on surface facilities, for example, among other things.

Higher thermal loading at repository edges. There are several models that are being worked on on thermal behavior in the mountain. The models suggest, as you might expect, as you get near the perimeter of the emplacement areas, because the heating is now at the edges from one side only or from underneath and one side and then you are out into the mountain outside the emplacement area and beyond, the temperatures come down, heating rates are less effective. So you get a different temperature profile around the edge.

One of the things that has been considered is, well, if that is the case, let's use higher thermal loadings in the perimeter areas and see if we can't kind of balance that out and get rid of that change in thermal profile. The current design does not use it.

We say here in a flat statement the "issue will not be revisited during the VA design period." I would suggest that I would be less adamant, if you will, about that statement. I think the door is still open. We are looking at performance issues. If we find on second look or if we get some additional information which suggests there is still maybe some benefit there, I think we would go take another look. Right now we don't think maybe it's as promising as we had hoped.

Ventilation. There has been some discussion about this. Currently we are not anticipating forced ventilation or mechanical systems for ventilation in emplacement drifts. Again, this is under consideration. This is where we are right now. We know that we are going to get some natural circulation and some natural ventilation in the emplacement drifts even though we don't put mechanical systems in place.

All things considered, all things being maintainability, operability, retrievability, other thermal considerations, all those things, whether this is adequate or not we're not sure yet. We are still working on that.

If we find that we need ventilation in the emplacement drifts over extended periods of time, it does have major significance because it means that you have got to have a mechanical system in place and operable and therefore supportable and justifiable to the NRC. It's a major operational consideration for us to deal with. So we are still looking at it.

[Slide.]

DR. SNELL: A couple of the operational techniques that we have looked at. The terminology here talks about linear mean loading, LML. There are more, but there are a couple of different ways that we have looked at as far as how you would put the waste in. In the advanced conceptual design, the left-hand part of the figure there, we put the waste packages in with a relative uniform spacing, the same type of package perhaps over an extended period in the emplacement drifts 22.5 meters center to center, more or less a square pattern, so called.

One of the things that is being looked at is a so-called line loading concept, the one that is portrayed on the right where you put the packages end to end and you intersperse some of the high thermal loading packages with low thermal loading packages. Defense high-level, for example, or some other spent nuclear fuel package. You put the drifts farther apart because you are talking about higher heat release figures and you want to maintain a thermal level that is consistent with those goals we talked about earlier, 350 and 200, and so on.

It is doable. It adds complications in terms of emplacement techniques. It may add complications in terms of retrievability because, for example, we might find out that we want to do retrieval on certain kinds of packages, not everything. Then you would have to leapfrog into a drift to get the stuff you want. Those are some of the things we still have to think about.

From a thermal management standpoint, it is an option; it is still being reviewed; and there may be some benefit to us in terms of the overall thermal strategy.

The use of low thermal output packages in between the higher thermal output packages does tend to drive overall temperatures higher. It is a little bit higher localized heat release. So it does have a bearing, first of all, on the center-to-center dimension on the drifts, which is shown, and may have a bearing on the thermal loading in the larger packages. Whether you go literally end to end on the packages or spread them a little bit, we are still working on that.

[Slide.]

DR. SNELL: Some of those operational considerations that I have been talking about are referred to here. The sequencing issue. But there is another aspect here that is worth noting, and that is that when you look at the aspect of filling the drifts, if you go in and fill a whole drift that is one thing. If you choose to work on filling several drifts simultaneously, that gives you a little bit different operational scheme, different temperature considerations, different ventilation considerations. A fairly complicated issue to look at, but it is all under consideration right now in connection with the thermal management.

[Slide.]

DR. SNELL: This top bullet says that the current designs and performance assessments are based on a percolation flux of 0 to 0.3, which is nominally the case. We are getting some data now, as you have all heard, which suggest that higher fluxes are quite possible. I guess we are not quite saying yet it is absolutely to be expected, but that is kind of the trend that we are in.

The suggestion is that if you look at the work that has been done, preliminary calculations, at 83 MTU per acre, which as I mentioned was kind of the target number that we are working with, at 1 to 5 millimeters per year infiltration flux we would probably get somewhat less dryout and less relative humidity reduction than we had previously anticipated.

[Slide.]

DR. SNELL: We have some options.

We could increase the thermal loading to offset the flux change.

We can go the other way and decrease the thermal loading and use more robust waste package materials.

There is a third option, and that is stick pretty much where we are right now with something around 80 or slightly above as a thermal loading and make that work. By that I mean we have some other characteristics that are related to thermal management which we can use in order to make that a viable scheme for the design.

Obviously it is important to VA. It is going to get a great deal of attention over this next year.

[Slide.]

DR. SNELL: Where we are right now.

Decisions made. Those are decisions for the time being, current basis, 80 to 100 is still nominally where we are. Probably 80 is closer to the working number.

This says "selected most thermal management options for VA." Still looking at line loading. I think again I would soften that up a little bit. I think the performance is critically important. We are getting new data from science and PA all the time. We have some options in mind, but we are looking at them. We are prepared to modify them where it looks attractive to do so.

We do have what I think is a pretty good and pretty comprehensive program in both corrosion testing and in some of the thermal testing work in the alcove, and so on. Ongoing we expect to get some pretty good data from that over the next year especially.

So we have got, I think, a reasonably comprehensive program in place right now.

That is all I wanted to say at the moment, and I will ask if you have some questions you would like to ask at this point.

DR. CORDING: Thank you very much, Dick.

Questions from the Board.

Don Langmuir.

DR. LANGMUIR: Dick, you spent some time telling us about consideration of zeolites and trying to protect them from breakdown.

DR. SNELL: Yes.

DR. LANGMUIR: But you didn't indicate or I didn't catch what you would be doing or might do in the design of the repository that would be a cost factor in order to keep that limit at 90 degrees at the zeolite horizons. Is there a cost factor that we need to consider? Does it increase our cost significantly?

DR. SNELL: Based on what I know right now, I don't think it does, no. As I mentioned, the numbers that I put forward in protecting the zeolites I think are really conservative numbers, and I think as we refine those it appears that we can use the thermal management strategy and take the other approaches that we are intending to take without any special engineering or construction actions and we will not damage any of the zeolites; we can preserve them with out a cost delta.

DR. LANGMUIR: There are a couple of considerations on the zeolites, as I understand it. I wonder if one is even a consideration at all anymore, and that is the possibility they will adsorb significant amounts of radionuclides. I doubt that that is relevant. Cesium and strontium they will adsorb and they will be gone in 100 years or so. I am reminded that neptunium may be adsorbed, but if I can make it ten to the fourth less soluble it won't matter; you won't need it for that, and you wouldn't need at a sorption barrier.

The other effect it apparently has is a potential source of a lot of water. So if you break up the zeolites at high temperature they dehydrate. There have been a numbers from Los Alamos on the volumes of water you might release, which could be an issue in terms of performance.

Have you considered that aspect of their behavior as an issue at all in thermal loading?

DR. SNELL: As far as water generation, no, I had not. Some of our folks perhaps have, but we haven't looked at it as yet.

To go to your first point, if it turns out that we don't need it, that is, it doesn't really provide significant benefit to us from the standpoint of performance overall, if the situation is such that is absorbs the wrong nuclides or ones that are taken care of in other ways, no big benefit for us, that is good news in one respect. We won't have to use extraordinary measures then to preserve them.

DR. LANGMUIR: But you are not using them, as you say, anyway. So it doesn't matter. You have not pointed out there was anything you were going to do to change what you intended anyway. Your normal procedure as you planned it would provide that 90 degree buffer apparently as you currently design it.

DR. SNELL: The reason that we are taking that approach is just prudence. I don't want to degrade or damage or impact any of the natural features if we can avoid it, and it appears with the assumptions that we have made that we can preserve that natural feature without any extraordinary measures from an engineering construction standpoint. So the approach is okay. We will go ahead with what we have right now. We will use these as design basis numbers for us.

If it should turn out that we are forced to go to some extraordinary measures and therefore we have big cost drivers or some other performance impact in order to preserve the zeolites and further the zeolites don't provide major benefit to us, then I think we would have to revisit that; we might want to change our assumptions.

DR. LANGMUIR: I would be curious. I don't know whether Julie Canepa remembers the report, but I thought there was a recent Los Alamos paper indicating large volumes of water might come off the zeolites under high thermal loading. Would she comment on that if you can't, Richard?

DR. CANEPA: Don, I knew you were going to ask me a question I didn't know. Yes, you are right. Our input to the near-field report and some of the systems work did show a fairly large volume of water that would come off. The impact I can't speak to.

I think that the thermal data that Bish has been providing to the systems people and why we would like to keep it at 90 degrees is because we are more interested in whether the zeolites may dehydrate but will they rehydrate. I think we would prefer to maintain that mineral stability so it can rehydrate so you don't promote other alteration of the zeolites.

DR. LANGMUIR: So it's the hydration issue as much as anything else.

DR. CANEPA: Yes, because then you are starting into some of the kinetic work that you might hear from Bish and his colleagues. We are not anxious to have the zeolites transform to something that is less sorptive.

DR. CORDING: Thanks, Julie.

DR. CANTLON: Earlier there was apparently two data sets one of which forecast high humidity at high temperature and another one somewhat lower. Has that been resolved now to your satisfaction?

DR. SNELL: My answer is probably not. I'm not familiar with the specific references that you are alluding to. I recognize that the work is out there and there have been different approaches. The whole issue of drift humidity and what we are likely to see in my mind is still wide open. I don't think we are at any point yet in design or at least I'm comfortable that we are in the right place. We have got a lot of evaluations to do.

DR. CANTLON: A follow-up question on the corrosion experiments. Again, the welds are a sensitive part of the package and sensitive to corrosion. Are you comfortable that the corrosion experiments have incorporated enough of that to get a real measure of it?

DR. SNELL: I am embarrassed to say I'm not sure how many weld quality coupons we have got in there. Hugh, if you are familiar.

DR. BENTON: The corrosion testing includes both samples of one metal and then welded samples or at least joining the two metals together. We expect to follow those closely to see whether there is any deleterious effect of corrosion on the welded sections.

DR. CORDING: Russ McFarland.

DR. McFARLAND: Several years ago when Livermore, Tom and Jim and others generated the line loading concept one logic that was very appealing at the time was that as the heat mobilizes the water in the near field you had point loading 20 meter separated packages and a hot package next to a cold package. It was stated there was a high probability that you could mobilize this water into the colder package. Has something changed? Has thinking changed on this with regard to the potential for mobilizing water away from a hot package towards a cold package?

DR. SNELL: I think there may have been some changes. I will ask a couple of people that may be here to comment further. In the early models that Buscheck was doing, for example, when you looked at high heat output packages and spacings of 20, 30 or 40 meters apart and you looked at the pictorial, if you will, it looked like you had over each package a little umbrella, kind of the reverse of an umbrella, but kind of a little umbrella. The tendency would be shed water into the intervening spaces and you could maybe create that.

A couple of things have happened. First of all, there has been a lot of coordination on the thermal modeling effort. Buscheck and two or three others that have worked the models have compared notes. One of the things that has gotten more attention recently is the same basic assumptions are being used by the different modelers in how they construct their models. In some of the early work the assumptions used in creating models were quite different for the same basic set of conditions.

I think that umbrella kind of concept, while it might still be there under certain circumstances, is probably a less likely forecast right now. The tendency, however, is still there.

I think with some of the line loading concepts or, for that matter, some of the other loading concepts that we are looking at with the spacing, with control of the spacing in some of the modeling information now, I think we are getting away from that probability. Moreover, I would say that we don't want to create a situation where we have got heat driving moisture off of one package and down the drift a ways and right back down into the drift on another package. Obviously that is a bad situation.

If the models as we work them tell us that that is still a possibility, I think we need to change our emplacement approach. I think we either need to move those high heat release packages closer together so we get rid of those gaps between the umbrellas, if you will, or make some other change in order not to have that happen to us.

DR. CORDING: Have you at this point settled on the type of lining you would like to test in the drift scale heater test?

DR. SNELL: Yes. We have selected one. We are still talking with the Repository Consulting Board about this. Some of the work on the cementitious materials is also relevant. In a couple of recent meetings with the consulting board we talked about three possible lining types in the thermal test.

One was a steel set lining with mesh or some other ground control material in between the steel sets.

Another option was a cast-in-place concrete.

A third option was precast concrete.

We recognize that with cementitious materials there are some questions about the chemistry of cements and therefore you might, well, is that the right kind of a test to run?

Jean Younker's people in performance assessment and some of the science folks are looking at various kinds of cements. We have talked with some folks from AECL in Canada, I believe, and others about cementitious materials. We think, based on information that has become available so far, that those still look like viable materials to use in the repository. You can do concrete mixes that give you relatively lower pH's from those that you would conventionally get by doping the mixes with additives.

Given that concrete is still viable, we originally intended to test all three types, a steel set, a precast, and a cast in place. Based on discussions with our own people and those on the board, the logic goes something like this. The use of steel sets as a ground support for the repository long term is probably unlikely, or it is a less likely option, we think, than concretes, partly because of corrosion conditions and some of the thermal conditions. So a concrete liner is the more likely.

In looking at the excavation methods that they use for the thermal test alcove, the tunneling technique gives you a rougher finish. It's a drill and blast. It is a rougher finish than you would get out of a tunnel boring machine. If you use a rough finish and try and put a precast section against that rough finish, it's a difficult situation and probably not representative of what you would get in the repository. In order to smooth it out or simulate what you get out of a TBM you have to go in and put something behind it, maybe a spray coat of some kind.

DR. CORDING: Another lining.

DR. SNELL: Another lining. If you do that, you lose the similarity with the precast section.

Moreover, the attitude was if precast behaves well in this environment, our expectation -- this is kind of a collective view, I think, technically from the folks working on this -- our expectation is that a precast segment liner would work even better. It is going to be at least as good as a precast section and probably better. I think the reason they expect it to be better is because of its ability to squirm a little bit, that is, respond better to whatever ground motion you might get as a result of thermal action, and so forth.

DR. CORDING: The precast being better than the cast in place?

DR. SNELL: Better than cast in place, right.

With those kinds of conclusions, we said, well, let's look at a cast-in-place test section in this thermal test. If it works well and we decide we like precast for various reasons, it ought to be a good deal better than what we have done in this test. Those are the two most likely. Right now it is the cast-in-place concrete test section.

Incidentally, in the front end where they are doing a lot of the thermal and hydrologic testing there is some conventional ground support. They are using mesh and so forth there.

DR. CORDING: That's good.

One thing I have observed in cases where the ground comes in on support, not in a thermal case, but where the ground was continuing to push in on support systems is that in many cases it wasn't the fact that you had high ring loads; it was the fact that you had a surface behind the lining that had variable stiffness and perhaps a loosened zone in the crown, which can be very common, or incomplete filling of grout or whatever behind the lining. So as the ground loads or the thermal stresses would come on, as you put compression on the lining there is a tendency for it to move into the low stiffness areas, and that can create bending and cracking.

Ultimately I think the performance of these continuous systems depends very strongly on what sort of contact you have around the lining and how well it is bonded or tied to the ground in terms of not having gaps present. I think that is probably going to turn out to be -- it might be one of the features you can even observe as you do the thermal tests.

DR. SNELL: I agree. I get nervous just looking at even relatively smooth ground behind a liner that is going to go in precast. Just the idea that you have got irregularities, rough spots, high points, low points, and those give you point loads and other unhappy circumstances on the structure you put in.

DR. CORDING: Thank you.

Other questions? Bill Barnard.

DR. BARNARD: During Dick's response to John Cantlon's question it seemed like Jean Younker wanted to add a few details.

DR. CORDING: Jean, I'm sorry I didn't see your signals.

DR. YOUNKER: Jean Younker, M&O. Thanks for watching out for me, Bill.

I think he really did come back and answer the question completely. I think what Dr. Cantlon was referring to was at the time that TSPA-95 was completed, just in the final review we had come up with a situation where some modeling that Tom Buscheck had done on relative humidities predicted quite different relative humidity in the near field than what we had used in TSPA-95. We had our people work very closely with Tom to figure out what the difference were. They have now come together in agreement and we use exactly the same approach now as what Tom uses in his modeling.

It had to do with assumptions, with the way the modeling was set up, with the gridding. It had to do with the actual way the models were constructed. They are now coincident. We don't think we have any more gaps in that.

DR. CANTLON: In which direction, high or low?

DR. YOUNKER: We kind of met in the middle.

DR. CORDING: Thank you very much. Thank you also, Dick, for your presentation. We are little head of schedule. I think we will go directly to our public comment session or any other questions that are of a more general nature.

DR. SNELL: May I make one or two overall comments?

DR. CORDING: Please. You're going to summarize for us.

DR. SNELL: Listening to the questions and the back and forth during the sessions there are some general comments I would like to make, and I will make them brief.

A lot of what we are doing now is in a formative state. We are in a preliminary conceptual. You may get the impression at times that it is awfully loose.

I guess the point I wanted to make is that as we go forward, particularly in 1997, we are going to set some design bases, that is, get them committed to writing so that it's a little easier to say this is what we are using here, here, here, and so forth, as opposed to saying, well, we're still working on that and we'll get back to you. We will be formalizing the design bases as we go forward.

With reliability, maintainability issues clearly a major effort, I just wanted to comment that, as I alluded to earlier, there will be a reliability, availability, maintainability effort as a normal part of the design. There was a comment about the fact that there is probably some pretty good history in some other programs that may be beneficial to us. The community of technique folks that work in that area do talk to one another a great deal. So I would hope to capture a lot of that operational and availability, maintainability experience from other programs as we go forward and formalize some of this RAM work.

You commented at various times that technology changes. Clearly it does. This is a long-range program. We are talking about a long time. So I think as we go forward one of the things we want to recognize and will recognize is that there are going to be changes; we need to maybe even come up with some kind of a structured or formalized way to assess technology changes and see if they can't be applied to the program as we go forward. We don't want to get ourselves locked in and say, no, no, we can't ever consider anything different, because as we have already done it that way, I think I would like to keep the options open when we reasonably can. So I think we want to do something on that.

Just as a general comment related to thermal strategy and some of the other issues that pertain to it, we really haven't done very much yet in terms of looking at the design particulars in the drift and in the design details in the drift.

You talked about things like getting water in behind the liner, and so forth. There are a lot of things that we can do from a design standpoint if we need to to help us. In other words, cause water to be shed around the drift as opposed to allowing it to drip; how we handle drainage features in the drift design; whether we want to put material additives in the bottom of the drifts or modify the invert designs that we have talked about. There are a whole host of things that we can do. We will get to them. There are a number of beneficial things that are available to us we will talk about some more.

One other comment I wanted to make has to do with the kind of a facility we have here. One hundred and twenty miles of drifts in the underground is a lot of underground. The good news is that any time you are doing a repetitive design, and these are in many ways repetitive even though Mother Nature changes the particular in each drift that you get into, there really are some major advantages. You can do a lot of intensive engineering on a typical drift, if you want to call it that, and really come in with good refinements, very careful analyses.

It pays off huge dividends because you take that intensive work on one or two or three basic designs and then you can apply it multiple times and there is a lot of money to be saved and a lot of time to be saved in doing that. That is one of the things we want to take advantage of.

With that I will be quiet.

DR. CORDING: Thank you. We really have seen some real progress in the repository design concept and you have been able to make modifications from the conceptual design that you put out earlier in the year.

I think we also very much appreciate this identification of key issues that you have. It provides us with a list of items that we can discuss with you at future meetings. I think that is going to be very helpful to us. We can focus on various of these key issues and your identification of them certainly brings that to prominence in view of the program, I think, in terms of your own interactions. I think that has been a very helpful part of the development of the repository design itself.

Let's go now to the public comment. Any general comments that people on the board or in the audience wish to make, we will entertain those at this point.

Do we have anyone signed up at this point for comment?

[No response.]

DR. CORDING: No one signed up, but that does not prohibit people from commenting at this point. We will go back to the Board and let Jared Cohon comment.

DR. COHON: We saw yesterday for the first time a detailed schedule for the program, the long-range plan all the way through licensing the LA. The press of time did not give Steve Brocoum and his colleagues a chance to respond fully to the question I asked about whether that chart that we saw and what lies under it had been subjected to the critical path method or other similar models and what could be used and learned from them. I have this feeling that Richard Craun might be prepared to say something more in that regard.

DR. CRAUN: Richard Craun, DOE. That is twice in the last couple of months I volunteered.

What I wanted to do was just share with you in going through and trying to establish the mission of the VA office one of the things we are looking at is trying to figure out a way in which we can track and provide Dr. Dreyfus and other senior managers the information on how are we doing on VA. In order to do that, what we have started identifying, one, we have a schedule, but we are looking at going through that schedule and identifying those key activities, those critical activities that need to be performed over the next two-year period of time in order to reduce the uncertainties, to improve our understanding and our documentation associated with the waste isolation strategy.

We are in the process now of identifying those activities and relating them to the waste isolation strategy. We will end up developing what I call an inner core of activities associated with the viability assessment. Those activities will help us focus on the uncertainties that need to be reduced between now and the end of 1998.

It doesn't mean that the remainder of the VA activities are not essential. By that I mean, for example, as presented by the engineering personnel today, that the surface design since we switched from an MPC to a canistered fuel will have to have general layout drawings in order to have the cost estimates associated with the VA. So those elements, even though they aren't directly related to reductions of uncertainty, they need to be done in order to have a viability assessment.

We are in that process of identifying the key issues that we are wanting to similar to what engineering has done but doing that across the project and then developing that inner logic associated with the schedule that we have currently available.

So those are the activities that we are pulling together. That will allow us to not only look at critical path. Once you develop that inner schedule or logic, that will allow you to look at some risk assessments. For example, if you have variable durations, if you have a confidence of a duration of four months and a higher confidence that you can get it done in six months, we can look at some of those risk assessments associated with the schedule.

Those are some of the activities that are starting, the M&O is starting. They are well under way on those activities to pull together a detailed critical path assessment.

DR. CORDING: Thank you.

John Cantlon.

DR. CANTLON: Alden, I would like to raise this question. Has any thought been given to the possibility that the drift floors themselves will become water conduits.

DR. SEGREST: The emplacement drifts are designed with slope so that any water that does get in will run out into the access drifts rather than the emplacement drifts. So there is some consideration that water will move through them, yes.

DR. CANTLON: As a consequence, that also will mean there will be conduits for radionuclides at some future date concentrating the points of flux.

DR. SEGREST: There is a lot of consideration into what will be designed underneath the packages within the drifts as far as what kind of packing, what might be placed in the invert. There is a lot of consideration that is being factored into the performance assessment work that is being done. A lot of things are being considered there with the different types of materials, the impacts on those materials as far as slowing the transporter, retarding it, or whether it may increase it. It is all being looked at pretty close.

DR. CANTLON: The difficulty I see is the tradeoff between trying to manage the water intelligently and then paying the price of having concentrated and sped up the movement of radionuclides to the water table.

DR. SEGREST: There are some designs that we can use as far as materials that we would place in the invert. You can look in certain other industries as far as what they done, as far as how they have used the materials for lining trash dumps or filter systems or anything else to retard the motion or to contain the water within it. So we are looking at some of the technologies they use there as to how we might design the materials in the invert.

DR. CANTLON: The basic presumption is that the repository as a total layout is going to act as a retarded of the system, but if you have now designed it to accelerate drainage, it isn't going to work that way.

DR. CORDING: Thank you.

Any other comments from the floor?

Richard Parazek.

DR. PARIZEK: I had one question regarding the 100-year earthquake that Clarence Allen is implying probably will occur. For instance, on doors for the placement locations, if they get stuck. Is this being thought about in the design as to how you put placement doors in and open and close them as needed in the event of earthquakes, and so on?

DR. SEGREST: Yes, it is, and there will be a lot more work done on that. Right now the earthquake condition we have to deal with is a .75 G. That is not extremely firm. We feel it could move up or down a little bit but not a great deal.

Additionally, we are expecting to be able to use attenuation with depth so that at the repository horizon we may only have to deal with something on the order of half that magnitude earthquake.

With those considerations, any operating equipment or devices in the repository are likely to have to be seismically designed to those levels.

DR. PARIZEK: There is quite a bit of thought given to the repository layout. Maybe the way in which it would be developed -- I will give you an example. We have a desire to mine stone and we first may quarry the stone because we can get a lot of money back in a hurry. Then we go deep and we continue to mine stone. Then we bring the water with us and for the next 45 years we are fighting the water problem that we induced because we went for the profitmaking stone first.

Here in the repository you have now two access ways for placement drifts, which is a change from maybe having only one. Then the idea of the whole ventilation system and access as you create it in time may cost you a lot of money if you do it one way first versus having had a choice to do it another way if you thought about it. I am sure that is probably in the thinking right now of all the options you have for how to develop this repository to save money in the time of tunneling and placement. I think a couple earlier illustrations showed waste being placed right up close to the access tunnel. Is that the place you should begin, or should you begin further south, as an example?

These are kind of interesting points. You might save money in the long run in running this place if you start putting waste in one part of it versus another part of it.

DR. SEGREST: Indeed. In fact in the sequence of construction events we are assuming emplacement through the north portal. Of course the emplacement begins long before construction is complete. So we are actually constructing north to south.

There has been some discussion of using the south ramp for emplacement and the north ramp for construction. We thought about it some, but our current plans are still to maintain the construction from the north to south direction.

DR. PARIZEK: Beside the welded joints on the waste packages and the canister there is the question of the stress points on the pedestals. If water gets in contact with the canisters in the vicinity of these pedestals and that is where the weight is being borne on those, is that going to be kind of a hot spot for corrosion and how does one address that kind of problem?

It seems like the corrosion experiments are small pieces. Now we know it is also welded pieces and two layers and one layer, but when you subject the whole thing to stress, you have got to somehow see where the weak parts are going to be with that real package being placed in those emplacement drifts and sitting there on the pedestal with water puddling in at the contact through time, unless that is where the shield comes, and then that is where the liner comes. Maybe that solves that problem for you. But it seems like there are some very important things that need to be talked about here. Or thought about.

DR. SEGREST: Hugh, did you want to respond to that?

DR. BENTON: We certainly agree that there are many considerations that we need to think about. For instance, the height of the pedestal. We would like to have the height low so that if for whatever reason a waste package comes off of one pedestal we don't get a very severe tilt to the waste package, which could in the long run exacerbate the criticality control analysis.

On the other hand, we want it high enough so that there is little chance of puddling underneath one of the pedestals.

So those things are being considered. In our analysis of the waste package we will consider the stress conditions in the weld area, in the pedestal area, and everywhere else.

DR. CORDING: Thank you.

John Arendt.

DR. ARENDT: I have got a question on the viability assessment. When that is due, will there be a design package? Is there going to be a big stack of drawings that are going to be available that one could go ahead and design the repository and all the equipment or even purchase equipment that is going to be needed? What actually will be in that viability assessment package?

I have heard there is going to be a letter and the letter will say, well, there are design drawings and there is a cost estimate, but what do you anticipate will be available in terms of a design package, drawings?

DR. SNELL: I am going to start a response and I will let Jack Bailey pick it up wherever he wants to, because we have been working on this for a while now.

We still have not with DOE fully set the exact contents of the package, but I will say that the work that we are doing toward viability assessment also has merit for license application. Jack did mention I think yesterday we are talking about a one-pass design. We will begin designs now. We are going to carry them forward all the way beyond VA.

What is available at the time of VA will be a set of design information, I will say, which will include some drawings and some specification information, which I will call not to think of in terms of finished specs but performance requirements information on major components of the design. They would be the forerunners of the specifications, if you will.

The approach that we are using is that we have talked about binning the design activities, putting things in bins, bin 3, bin 2, bin 1.

Bin 3 items are those that we believe are especially critical for performance and items for which there is not a great deal of precedent with the NRC. So we are focusing a good deal of attention on those.

So-called bin 2 items are those where they are important, they have safety implications, but for which there may be a little more precedent already existing in the industry.

Bin 1 items are those which are relatively straightforward or conventional items.

Given the fact that we want to work on the most sensitive items and those with lack of precedent first, the package at viability assessment will have a higher content of those bins 3 or sensitive items, an intermediate content of the bin 2 items, and relatively little of bin 1, because they are fairly straightforward. There will be enough of the latter so that we can support the cost estimates. There was a reference to that earlier.

The state of completion on bin 3 items will be more advanced than those on bin 2 and further bin 2 more advanced than those on bin 1.

So what you will have will be the letter, if you will, that Dan Dreyfus would submit, the attachments to the letter, the design, the TSPA, the estimate and the licensing plan, and then in the design package a set of information which would be partially complete drawings, and, as I say, a larger percentage of the bin 3, lesser for bin 2, a little bit of bin 1, and state of completion highest on bin 3.

In terms of an overall completion on design, a relatively low percentage of the total design reflected at the time of VA. We will have enough information there so that one can clearly understand the basis for the TSPA for the performance assessment and enough information to easily support the cost estimate, because you need some basis on which to prepare those costs. And I think there may be some of it which would be illustrative of what is needed for the license application and the LA planning.

That is about it.

DR. CORDING: Thank you very much. We are ready to close our session. Particularly I would like to comment on behalf of the Board in thanking Dr. Dreyfus, the DOE staff and the presenters for their assistance in developing the agenda for this meeting, for their participation, and for the quality of the presentations we received in the past two days. We very much appreciated the opportunity to have the extra time to engage in discussions with the presenters. We appreciate their willingness to do that also.

Certainly we see much progress in the program. We see much more of a focus on key issues. Things appear to me to be converging, that we are coming toward solutions as the program approaches the viability assessment and as it looks forward to a suitability determination.

We received information yesterday on the program plan, Dr. Dreyfus' presentation, and then Steve Brocoum's discussion of the activities for the next year. We see, I think, a clarification of the plan.

Then, as we look at other aspects, the performance assessment and increased integration, increased emphasis on that, and the continuing effort in the area, which certainly has to be a continuing one, we see a bringing together of some of the scientific concerns and the designs, the things that we have learned today with the plans for the repository design and operation and the identification of those key issues.

The other area yesterday that we focused on was site characterization studies. We appreciate receiving the updates, not just on what has been done or what the plan is, but what does it mean. The data is being collected. It has to be evaluated in real time. It seems to us that that is happening.

Of particular concern is the relationship between the geologic conditions underground, site conditions, rock characteristics, structure, and moisture flux and the transport into, through and out of the repository. In that area we are looking forward to additional progress as the work goes forward this year. We recognize that you are on a very steep curve; there is much being obtained, much remaining to be completed. We look forward to hearing of those plans for the further exploration and testing and evaluation of things such as the ambient moisture conditions and flux.

Again, we thank you very much and we appreciate the opportunity to interact with you and the effort that you have made to do that with us.

I would like now to turn the meeting over to our Board Chairman, Dr. John Cantlon.

DR. CANTLON: I don't need to say much more than Ed has already said. We certainly thank the M&O people and the DOE people for providing us with this update. We will look forward to the next iteration. I have the joy of being able to adjourn this session.

[Whereupon, at 12:40 p.m., the meeting was concluded.]