UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD

A MEETING OF

PANEL ON
THE ENGINEERED BARRIER SYSTEM

Richmond Room,
Augusta Sheraton,
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Augusta, Georgia

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CONTENTS

P R O C E E D I N G S

DR. DEERE: Good morning, ladies and gentlemen.

I am Don Deere, Chairman of the U.S. Nuclear Waste Technical Review Board.

Our board meets four times a year in full session, but the majority of the work gets done in smaller meetings, in meetings of our panels. There are seven technical panels within our board, and the meeting you're attending today is the meeting of one of these panels.

Each panel meets from one to as much as four or five times a year, and tries to assimilate the material and the dialogues with DOE and other interested parties, and then present them to the full board for their consideration and for inclusion in some form in our reports to Congress and to the secretary.

I will turn the meeting over now to the Chairman of the Panel on the Engineered Barrier System, Dr. Ellis Verink, and he will chair the remainder of the meeting.

Ellis.

CHAIRMAN VERINK: Thank you, Don.

I am Ellis Verink, a member of the Nuclear Waste Technical Review Board, and Chair of the Panel on the Engineered Barrier System.

On behalf of my colleagues on the panel and myself, I certainly wish to welcome you to this meeting and thank you for taking the time to attend and to participate in it.

The board was created in 1987 by an act of the U.S. Congress, and the board consists of eleven scientists and engineers nominated by the National Academy of Sciences and appointed by the president.

The board's function is to evaluate the technical and scientific validity of DOE's activities under the Nuclear Waste Policy Act, as amended, and to advise Congress and the Secretary of Energy of our findings and recommendations. In simplest terms, we are an independent peer review body.

We are required to report to Congress and the Secretary of Energy at least twice a year. Four of these reports already have been presented, and we're now working on the fifth report.

For those of you who may not be familiar with the board, I would like to point out that we have had -- or we used to have, maybe we still have out there some literature on the outside table. It was going pretty fast the last time I looked.

Bill Barnard, our Executive Director, and Nancy Derr back in the back would be the ones to contact if you would like to discuss the board, or its history, or its mission, or get some additional information about the board's activities.

I do need to repeat that our mission is simply one of technical and scientific evaluation of the DOE's activities regarding its program to manage the disposal of spent fuel from utility nuclear reactors.

Now, because some small portion of the nuclear waste to be disposed of may consist of defense high-level waste from reprocessing, a portion of today's meeting will deal with this waste form as well, and tomorrow the board will be touring the Savannah River Plant.

However, let me underscore the fact that the board has nothing to do with things like the restart of the Savannah River Plant defense reactor or environmental operations at Savannah River.

After the formal presentations, time will be allowed for questions from members of the board and staff, and they will ask the first questions. If time permits, the public will be asked to make any comments or questions that they may have, and I would ask that any questions or comments during the public participation period be kept in line with the board's mission.

I have a few introductions. You have already met Dr. Deere.

I would like to introduce Dennis Price who is right here. He is a distinguished board colleague, and he's at Virginia Tech. He's the Chairman of the Transportation and Systems Panel, and a member of the Engineered Barriers Panel.

Several members of the board staff are also here. Most of them are quite familiar to you. You have no doubt been talking with a group that are here at the table, Leon Reiter, Russ McFarland, Bill Barnard and Jack Parry.

We have two new members of the board, however, two new faces that you may or may not have known. Carl Di Bella is right here, and he has joined the senior professional staff only three weeks ago. His principal duties will be to assist the Engineered Barrier Systems Panel.

The other member is Bob Luce who joined us just last week, and he will be assisting the board's Panel on Hydrogeology and Geochemistry.

I am particularly looking forward to today's meeting because although the board, its panels and its members and individuals have participated in many formal and informal meetings over the last months where engineered barriers were an important topic, this meeting actually is the first so-called official meeting of the EBS panel in more than a year.

Today's meeting will be roughly divided into two parts. As I mentioned a moment ago, we will be discussing defense waste. This will be the second part of our program, actually, and this morning we will be talking about the EBS program with the DOE and the M&O contractor.

Now, for those of you who may be new to the board's activities, the term "engineered barrier system" simply means the waste packages and the underground facility. That is the radioactive waste materials themselves, and any encapsulating or stabilizing matrix, any containers and any shielding or packing, or other absorbent materials immediately surrounding individual waste containers.

The term is used to distinguish between the constructed or engineered barrier to the migration of radioactive substance as distinguished from the natural or geological barriers.

Now, the board has made several conclusions and recommendations regarding engineered barriers, and I'd like to recount some of those for you just to kind of set history before us.

The board believes that the well-engineered structures are less variable, hence more predictable, than rock formations. Therefore, it should be possible to reduce overall uncertainty concerning a repository's long-term performance by relying on geological barriers in combination with more robust engineered barrier systems designed to retain the waste materials for thousands of years. This was first included in the second board report in November of 1990.

Studies of alternative waste package materials should be restarted, in our opinion. These studies should include evaluation of container materials and designs, emplacement designs, and container configurations, including both internal absorbing materials and external backfill materials, and this was also in the second report of the board.

The engineered barrier system development and testing program should be coordinated and funded at a level sufficient to produce a statistical basis for assessing its contribution to the long-term predictions of repository behavior.

Tests should be long-term, preferably exceeding five years, and include both laboratory and field testing. Again reported in the second board report.

Priority should be placed on developing a high-level waste management system that minimizes the handling of spent fuel. This recommendation is actually from the board's Panel on Transportation and Systems, of which I am a member, but could or should have some impact of course in the engineered barriers.

High priority should be assigned to developing a more robust engineered barrier system. This is from the third report.

The board strongly believes that the development of a long-lived engineered barrier system should be made a more important part of DOE's program, as indicated in the fourth report December of 1991.

The board also concludes that no technical obstacle has yet been identified to the design and development of an engineered barrier system that can be shown to have a reasonable assurance of isolating radioactive waste for thousands of years. This also is in the fourth report.

A number of concepts exist that could contribute to a robust long-lived engineered barrier system. These concepts should be thoroughly investigated in the opinion of the board.

Studies of the potential contribution of engineered barriers such as multipurpose canisters should not be deferred to a later date. EBS development and testing should be funded continuously at a level sufficient to evaluate its contribution to long-term predictions of repository behavior. This too was in the fourth report.

All these findings were agreed to and reached by the full board after careful deliberation. We will be keeping these findings in mind as we listen to this morning's presentations, and I'm sure this may color questions that may come up during the meeting.

The second half of today's meeting will cover defense high-level waste, and current plans are that such waste would be commingled with spent fuel from utility nuclear power plants in the first geological repository.

We are looking forward to hearing from DOE and Westinghouse Savannah River Company about their defense high-level waste activities and plans at the Savannah River Plant. We expect that what we will learn will be important to us in fulfilling our role as a board.

I would like to add that this is the first formal board activity at or near the Savannah River Plant. Thus, we are very pleased that the DOE has arranged for us to visit the plant and tour portions of the facility of highest interest to us. The visit and tour will not constitute a board meeting and, hence, will not be open to the public.

We are very pleased the meetings of the board and the panels are open to the public. This not only provides a valuable mechanism for the board to receive public input to help carry out its function, but it also gives the public a window on the board's activities.

You will note that the meeting is being recorded. Meeting transcripts will be available on a library loan basis from our Arlington, Virginia office a few weeks after this meeting.

A general comment for those of you who may be interested in raising questions or making comments, please use the microphone -- you'll notice there's one in the audience there, and that the board of course have their own -- and identify yourself for the record, give your name and association.

If you have picked up an agenda before the meeting, you'll see that we've got a full schedule. I would therefore like to remind you that the remarks and questions should be as short as possible and confined to today's subject matter.

Well, it is now time to go ahead with the meeting, and our first speaker is Mr. Steven Gomberg of the Department of Energy, Office of Civilian Radioactive Waste Management. Steve.

MR. GOMBERG: Thank you, Dr. Verink.

My name is Steve Gomberg, and I'm with the Office of Civilian Radioactive Waste Management. I am going to be giving some brief introductory remarks, and then turning it over for our speakers.

First let me thank the Office of Environmental Management, Environmental Restoration and Waste Management, the Savannah River Operations Office and Westinghouse for putting together presentations on DWPF and the Savannah River Site.

I would also like to thank the Technical Review Board for their interest and allowing us to come down here and present them this material, and also the public for attending and showing your interest.

Let me just briefly describe for those of you who don't know what we do at the Office of Civilian Radioactive Waste Management. Under the Department of Energy we manage the repository and MRS monitored retrievable storage transportation projects. We will provide disposal and transportation services established under the Nuclear Waste Policy Act, we will develop requirements for waste acceptance, approve the quality assurance programs of Office of Environmental Restoration and Waste Management, and we plan to accept approximately 7,000 metric tons of high-level waste glass from all the defense and commercial high-level waste glass facilities by the year 2010. That is roughly 10 percent of the total planned capacity of the repository.

Now, the Office of Environmental Restoration and Waste Management, our sister agency within DOE, manages waste vitrification activities of the Savannah River Operations Office.

They will produce a canistered high-level waste for silicated glass for pickup by our transportation system. They began cold testing of the glass in 1990, and plan to begin hot start-up operations by 1994, and we expect that we will be receiving approximately 5,750 canisters.

Very quickly I just wanted to go over the agenda. There has been a slight change in the agenda. The board has asked us to present a discussion on repository thermal loading that was to take the entire morning session.

One of the presentations on EBS development through license application was briefed to Dr. Bartlett, the Director of Civilian Radioactive Waste Management, on Friday. He felt that we were not ready to present the material at that time, so he has asked that we drop that presentation. That will provide more time to talk about the defense waste processing facility.

We will have a review, a preview of the previous meetings on thermal loading -- there were three of them that we presented to the board -- and we'll also discuss plans for conducting MRS system studies on thermal loading and other thermal tailoring issues.

A system study is a study that looks at all the elements of the nuclear waste management system, both the repositories and transportation systems.

After that DWPF, the Defense Waste Processing Facility, will give an overview, discuss their approach to waste acceptance, product control and quality assurance programs.

And then on the second day there will be a closed tour of the facility.

That's really all I wanted to say. I just wanted to get everything going, so Dick Morrissette from SAIC, the Yucca Mountain Project Office prime contractor, will be talking about the previous briefings that were given on the thermal loading issue.

MR. MORRISSETTE: Good morning. My name is Dick Morrissette, and I work with SAIC.

I have been involved with several of those TRB meetings, helping DOE put them together. The last one was the October meeting that we had on thermal loading, so as a result of that I was asked by Michael Clonninger to help him put his presentation together for this meeting, so we worked together for a couple months trying to find a way to say what we said over three days in less than an hour. We had thirty talks at that meeting.

Unfortunately, Mike had some surgery and couldn't be here, and that's the reason I'm here instead of him today. He would have liked to have been here to present this, but his doctor would not let him travel for a few more weeks, so he couldn't be here, so I will be Mike today.

As I said, we had several meetings on thermal loading, and what I'm going to try to do today is to guide you through some of the material that we went through.

There is a lot of material that was presented, and we have some people here that will assist me if you have a lot of technical questions, et cetera that I have a concern about answering, then we do have some people from Livermore, we have a representative from the M&O who is going to be, or is involved now with the EBS program, and I was hoping we would have somebody from Sandia, but I didn't confirm that.

Is Eric Leiter in the audience, or anybody else from Sandia?

We also have some other people from SAIC. I think Mike Voegle is supposed to be here, I haven't see him this morning. There he is. Okay.

So we have several people, and as I go through my talk I'm going to like I said summarize it rather quickly, but if there are specific topics that you want to stop and dwell on then we can do that. I think this meeting will provide an opportunity for us to revisit some of the areas that we had covered extensively in October, but albeit it was -- we had so much material to cover in October it went kind of fast.

Okay. This is an outline of the presentation.

We're going to talk a little bit about the prior meetings, their topic, and then revisit the thermal goals that we addressed in October, and after we've covered that we're going to focus on the thermal analysis that has been done to try to look at the various thermal loads, so we'll spend a little bit of time on that which will include both the work by Eric Ryder at Sandia and the work by Tom Buscheck at Livermore. We didn't really have a chance to dwell on that too much in October we had so much material to present.

Then we'll end off by talking about the effects of that thermal loading on the EBS, so we will get into all the areas where thermal loading may have an impact on the EBS.

We have had really only two meetings that discussed thermal loading. The first one was in March of 1990, and it was really an introductory meeting where there were two presentations given, one by Tom Blejwas of Sandia, and another one by Eric Ryder.

The discussions at that meeting were sort of introductory to what we really got into during the October meeting. Tom discussed a little bit about the temperature distributions throughout the repository, and Eric discussed the approach that he was using to calculate those temperature distributions.

Both of those topics were discussed extensively again in October, so I'm not really going to dwell too much on the March 1990 meeting.

The other meeting that I think the board wanted to discuss somewhat, which I don't have on the agenda here, was the meeting we had in June which was called the EBS workshop. I really have not spent too much -- I don't want to spend too much time at this meeting to get into that. I felt that the thermal loading question really wasn't addressed much at the EBS workshop. This was a workshop where we presented -- we asked people from outside the project to come in with potential concepts, and we presented a dozen or so new and novel concepts that were proposed by people not related to the project. There was also a lengthy presentation by Livermore National Lab where they presented a systems engineering approach and some of the concepts that had come out of that workshop.

The results of the workshop were recorded in an extended summary report which I believe was sent to everyone that attended that workshop some time in late December.

If there are questions, however, that someone wants to address on the workshop, we'd be very willing to discuss it if we have some open time either after my presentation or later this morning.

The October meeting was the one that we want to focus on, and these were the major topics that were covered there. The current reference thermal loading for the repository in Yucca Mountain, this was really the SCP-CDR concept. It goes back to the late eighties time frame, '88, '89 where we presented a conceptual design of the repository in the SCP, as part of the SCP. The rationale for that was, and the history was discussed at great length.

The board had also invited some participation from other countries, and we heard from three different repository development programs from the Swedish, the Germans and the Canadians, and that was also very interesting, but I'm not going to dwell on either of those two topics today.

The main topic I want to focus on is the issues, considerations and implications of lower and higher thermal loading as it relates to our repository.

Getting right into the crux of the matter, we will again revisit a set of formal goals that were established during the SCP time period, and these are the formal goals that were used for the work that was recently done for the October meeting.

They gave us some targets that allowed us to look at different areal higher densities and determine whether we were still within these guidelines, and they are strictly guidelines and I believe that as we look at thermal loading we really have to first look at these thermal goals and determine whether they are the right goals, and possibly we may want to adjust these as we move along and get more information through site characterization.

We have a thermal limit on the container centerline because we're concerned about the cladding, and I'll get into that in a little bit more detail in a minute.

We also have a temperature limit associated with the cladding that gives us a temperature of around 275 degrees C for the borehole wall.

We have a limit that we have established at one meter from the borehole wall. Again, I should say this represents the design that we had for the SCP which was a vertical emplacement within a borehole in the floor of the drift. So one meter from the wall of the borehole into the rock we were looking at limiting that temperature to less than 200 degrees C, and I'll talk a little bit about that in a couple of viewgraphs.

We were limiting the drift wall temperature just for having access to the underground during the post-closure period, and this has been looked at differently in recent work.

The interface between TSw2 and TSw3 is where the Calico Hills starts. There are some features about the Calico Hills part of the formation that we don't want to disturb, so we have set a limit there of 115 degrees C, and that temperature is being looked at as we speak.

Also, the surface environment was limited to 6 degrees C. In October we were able to show that we never even got close to this high of a temperature, and if we did it may be a problem from a biological standpoint.

It was reported in October that if we could stay within one or two degrees C from the ambient temperature that we would not have any problems from biological, so we're really much closer to the one or two-degree range there, and that one may come down.

We had a goal to try to maximize the time spent above boiling, try to have a dry environment within and around the waste packages.

Let's leave that one up here, and I'll go ahead and use this other machine here.

Focusing a little bit more on the 200 degrees one meter in from the borehole, this was calculation that was done to determine what the temperature was and to see if there would be any problems, and the basis was to try to reduce the potential for borehole collapse. They were more interested in here in the stability of the rock.

They do feel that they encountered some mineral phase changes that may occur around 200 or 250 degrees C. Some of these may actually occur a little earlier than that, so they felt that they really wanted to get up in this temperature range.

There was a thermal expansion analysis that was done to determine how much the rock might move inward if given a temperature drop from like 275 or so down to 200 degrees C, and simply looked at containing the rock one meter in and applying that Delta T across it to determine what the expansion might be inward into the borehole, and they found that they were only getting about five millimeters of movement as predicted by a thermal -- by the calculations. They felt that that small amount of movement was insignificant, so they thought at the time that the 200 degrees was quite conservative.

However, there still needs to be a lot of evaluation as to what that would be and how hot we want the rock to get around either the borehole or around the drift, especially from the stability standpoint, and we need to really try to understand the true magnitude of the space change because that might affect stability.

The actual stress/strain state at borehole surface needs to be looked at, and the potential for borehole failure, or to be more general any failure of surrounding rock, whether it be a borehole or a drift, because we are starting to think a little bit more about drift emplacement these days.

The other goal that we see up there is the 350 degrees C, less than. The main degradation mode that we're concerned about here is creep rupture, creep stress rupture, and that is the predominant mode, although there are several other modes of cladding failure this is the cladding that surrounds the fuel pellets.

As you receive the fuel from the reactors they are fuel assemblies made up of fuel rods, and the fuel rods are each clad in a Zircaloy -- most of them in Zircaloy. There's a few rods with stainless steel.

That cladding is there, and for a large percentage of the fuel, almost 100 percent these days, it's still a good structural container.

I did a calculation recently just to get a feel, put myself in perspective -- sometimes you need to get things in perspective -- and we have, for 70,000 metric tons there's going to be about 30 million fuel rods in the repository, so it's quite a few smaller containers of the fission products and actinides, et cetera, so we are very interested in seeing whether we can use that as one of the barriers, depending on how well we can predict how it's going to perform.

It was designed to perform in the reactor, not really designed to perform in a repository. At the time I believe when they were designing reactors they were hoping to reprocess the fuel, so they were going to just cut up the cladding.

So the predominant mode is creep/stress rupture, however as you may remember we had a meeting at Livermore in August of 1990 where we presented quite a bit of information on the waste forms, and there was a presentation there given by Ray Stout and other people on spent fuel, and they did go through in quite a bit of detail some of the degradation modes that you see on cladding that included, just to summarize some of these, the cladding has an oxide layer that provides a good protection to it, and also is under compressive load which keeps the cladding from creeping. The oxide protective layer can fail, and that would be one mode of failure.

The other thing we have to concern ourselves about is there's hydrogen that infiltrates the cladding during its operation, and the hydrogen can precipitate out as hydrides and depending on when and at what stress state the cladding is in that precipitation could be either beneficial or detrimental. If it's under some sort of a stress state, then the hydrides might precipitate out radially and actually cause some cracking to occur, so that's another area that we concern ourselves about.

Thirdly, we could have a Zircaloy fluoride reaction if we found that we had fluoride in the water in the repository.

And finally, this particular degradation mode here which we find is most dominant during the high thermal period, so there's been work done to focus on this mode, and actually there has been other studies.

Work on that started in the early eighties, and the work that I've quoted here is not validated but does represent one approach to the problem, but as early as September '84 A.J. Rothman presented or had a paper on the potential corrosion and degradation mechanisms for cladding. I could get a reference for you on that, it was a Livermore report.

During the period of time when DOE was supporting some research for commercial spent fuel storage either at reactors or in an MRS, something like an MRS, they wanted to know -- because most of these systems were going to be passive systems and they were going to be cooled by whatever -- they wanted to store in a dry environment and cooled by air and other media like that, so they asked PNL who was responsible for the commercial spent fuel storage studies to undertake a study to look at what the maximum temperature that you would want the fuel cladding to be at in a storage mode in an MRS or a reactor storage, and this work here sort of formed the basis for setting a temperature of 380 degrees C as a maximum where you would stay out of the problem of creep/stress rupture, and this was for a time frame of forty to fifty years.

Brian Chin at Auburn University was working with PNL on that and used a technique called the defamation factor methodology to do that and some analytical approach, and from that they derived this temperature. I believe they're using that in licensing now some of these facilities.

Later on in 1990 Livermore asked Brian to extend his work to look at what it would be like under repository conditions where we're not talking about forty or fifty years but we're talking about at least a thousand years, and using his same methodology he determined that we probably would want to lower the temperature around to the 300 to 340-degree max range, depending on the burn-up of the fuel and the pressure within the fuel cladding.

The pressurized water reactors actually pressurize their fuel rods, so they're running at pressure. In the reactor it actually doesn't see a lot of pressure because the pressure within the primary system counteracts the pressure within the fuel rod, but when you take it out of the reactor and you're storing it under atmospheric conditions then you have a positive pressure inside of the fuel rod that's pushing it up.

That was basically all I wanted to say about the goals at this time. We may want to bring them up and discuss them later.

I want to move on now to the thermal work that was done by Eric Ryder and Tom Buscheck.

A couple points I want to make here before we get started. I was involved with getting the October meeting going, and one of the things I felt that I probably could have done a little better on was we had some presentations the way the meeting was run where Eric Ryder presented different results of work he had done at various thermal loads, and then after we had an idea what the temperatures were like in the repository he showed us videos and did quite a marvelous job there. We went on and talked about the effects of that thermal load.

One of those areas we talked about was the hydrological area. However, Tom Buscheck had done quite a bit of thermal work himself independent -- I shouldn't say independent -- but using different models, et cetera than Eric had, and his work should have been brought up front and discussed with Eric's work, but it was sort of mixed in with his effects presentation and may have left some people a little bit confused, because he was trying to cover really two topics at one time.

Also it may have left people with the impression that we had decided to go to a very high thermal loading repository, and Mike wanted me to say that DOE is not advocating at this time either raising or lowering the thermal loading.

The SCP came out about 57 kilowatts per acre, and we're looking at what -- we're trying to gather information at different thermal loadings, either lower or higher to get a better understanding of all the things that are going on when you do that, so we're doing a lot of parametric studies, and the work that Eric and Tom did should be viewed that way. They are strictly parametric studies, and it's enlightened us quite a bit in some of the areas that we hadn't looked at before because we were strictly focused at one thermal loading, but now looking a range of thermal loadings we can see some of the things that are going on.

So these parametric studies are continuing, both Tom and Eric are doing work on that. Tom again would have liked to have been here, and from my personal standpoint I'd rather have him here to discuss his work than me, but unfortunately he also had an accident and he's recovering from surgery. I have a feeling that the waste package people have a high level for pain or something like that.

He fell of his bicycle, he's quite an avid bicycler. He could not be here himself, but we do have two people from Livermore who can address his work if we get into some questions.

Okay. With that we'll move on.

The SCP-CDR design is shown here. What we're doing is comparing different -- I call them scenarios because we haven't really -- this is the only reference design we have which was presented in the SCP. We're looking at changes to that. The design has evolved over the years and we're even looking at drift emplacement concepts, so the work that Eric was doing at Sandia as you remember in October modified the SCP design, and he looked a variety of thermal loadings from 22 kilowatts per acre up to 80, and it was basically the same basic design, a vertical emplacement, small waste package concept.

It was the intact hybrid that was described in the SCP as an alternate design. It had four intact boiling water reactor elements and three pressurized water reactor elements within one canister, basically a thin-wall metal canister.

We can see the effect of going from consolidated fuel to the intact increases the amount of canisters from 25,000, what we had in the SCP, to about 31,000.

Tom, however, was doing some work looking at not only drift, but trying to look at the entire repository and look at some other features of the thermal analysis that Eric hadn't looked at, and I'll get into that in a minute, but he did do some work using a drift emplacement which was the first time we had done that, and there were some interesting results there.

He again really didn't have the level of detail that Eric did, but one can infer from his work that we could have a waste package that could range from five, like 5 PWR, pressurized water reactor fuel package, to a 26 PWR. This would be a much larger package, and if you were to build such a large package you would actually cut the number of packages down approximately 7,000, and there's work going on now with the M&O to look at that, and this number is being looked at. It may be a little different than that, but the only point we want to make here is you do reduce the number of packages considerably when you go to a large package.

And Tom pretty much looked at the same. He went a little further than Eric did, looked at 114 kilowatt per acre case.

Other areas that the drift spacing was a little different, Tom's was more similar to the SCP and Eric put moved them in a little closer. That was because we were looking at older fuel now.

We'll talk a little bit about the two different models that they used. Neither of these have been validated, but they do provide a lot of insight in trying to make decisions, and will be used further and further developed.

I'm sorry Eric isn't here, he may -- I'm not sure whether he's planning on getting a paper on his model later this year, but I know that Tom is, and this will be an opportunity -- I'm sure all the board members will be going to the April meeting in Las Vegas, International High- Level

Radioactive Waste Meeting, it's going to be your third annual meeting -- and Tom has an extensive presentation there on his model and will be available to discuss that at that time.

The Sandia model is a conduction model. Eric did look at the impact of other things and felt they weren't too great, so I don't think it's too far off there, but it uses a three-dimensional linear superposition of heat generators. These are either point heat sources or cylinder, cylindrical heat sources.

He has the capability of emplacing the spent fuel into the repository as we planned to do it in a step-wise fashion over the 25-or-so-year period. His model does provide a good replication of what we believe is the geometry at least for the SCP-CDR design, so he's really got a good geometry built in his model.

Scaling of emplacement densities is done through his ED, effective energy deposition concept, and his models on the conduction.

In Eric's case -- I mean Tom's case he's got a two-phase hydrothermal model which is based on V-TOUGH code, and he's capable of looking at a variety of thermal analysis approaches, including conduction, convection, radiation, boiling and condensation.

He's actually got two different approaches that he uses. One is a repository scale model where he models the entire heat source as a solid disk, and depending on which power density he's at that size of the diameter of that disk may vary, but let's say in the 57 kilowatt case it would be the entire diameter of the repository, so it's a large flat disk and he's able to look at edge effects there as things occur.

He also did a drift scale model where using symmetry he models a typical drift with a waste package laying on the floor of the drift which is a line axially with the drift, so it's end to end. It would be like a shield, a self-shielded waste package which would be laying end to end along the drift, and he assumes in this case that he's got an infinite repository, it's just he replicates the symmetry, so he's not able to look at the edge effect quite as well and determine really what's happening in a little more detail.

About two-thirds I believe -- comparing these two models, this one is good for about the center two-thirds of the repository. When he gets out further than that, then he really has to rely on this model.

He also applies his heat load instantaneously, he doesn't have the ability in his model yet to do this step emplacement.

So there are basically two different approaches, and the results although in some cases may appear to be similar because they haven't been validated and the approaches are so different that we can't say that one is a validation of the other. They are not, they are just two separate approaches looking at the problem.

An interesting result that came out of Tom's model was this simple little table here that is kind of interesting. It compares different APDs, areal power densities, to different ages of fuel, and you can see the reference case that we're at here with the ten-year-old fuel, and that's what we assumed during the SCP days that we would have ten-year-old fuel. That gives us basically a normalization if we divide the areas by the reference case, and one can just look at the chart here and see how things vary as we age the fuel and as we either raise or lower the APD.

The aging -- looking down this way, the aging of the repository, or aging of the fuel allows us to actually increase the tonnage per acre, because by aging the fuel you get down that temperature curve if you remember, and I didn't really bring one, but the temperature output or the heat output goes down quite a bit with time. In the early years it's very steep.

As the fuel is taken out of the reactor it's putting out quite a bit of heat, in the first five years it drops way down, the next five years it drops quite a bit more, and it keeps going until you get out in the sixty to hundred-year range, so what's he's taken advantage of is by not putting ten-year-old fuel but putting thirty-year-old fuel he's avoided that peak, he's down on the flatter part of the curve, it allows him to move things closer together, and actually the amount of integrated heat that's going into the repository per unit area is greater and he's able to keep the repository warmer for a longer period of time, and it requires less area.

I found this one kind of interesting. This would be a very small repository, almost 10 percent, 15 percent of our current size.

To focus a little bit on the results that Eric Ryder had from Sandia -- and let me put this one back up here so you can see that at the same time -- these are our goals that Eric used to try to stay below, and this is a very short summary of what he presented.

As you remember, he presented a lot of information, sort of voluminous, he even had a video that showed the temperature growing over the years, but I'm just focusing here on the peak temperatures, because these relate to these over here.

He was looking at 22 kilowatts per acre to 80 kilowatts per acre, and in order to accomplish that here he's -- you know, currently with the delay in the repository we're really looking at more like thirty-year-old fuel rather than ten-year-old fuel, so these are kind of the reference now.

In order to get down to thirty kilowatts per acre he had to actually increase the age to sixty, and then at 22 he went to ninety, and the resultant output per container goes down.

The results here that we're really interested in was these temperatures and determine how they compared with that over there. We had a borehole wall temperature of 275 here, and currently we're not even near that temperature.

The other one was 200 degrees C for one meter radially, and in all cases he's well below that. The SCP for this case was actually instead of 275 was closer to 235, but even now we're quite a bit lower.

I was looking at the differences here, and as we get further out the difference between the Delta T across that one meter is coming down. Here we're down to about four degrees Delta T, so there's quite a bit less difference in thermal expansion there. Here in the reference case we're around twelve degrees Delta T.

I thought also that this was kind of interesting. We're currently running at 94 degrees Centigrade. This is the distance below the repository, about the point where the

Calico Hills starts, at one end of the repository, so this relates to this 115 degrees that we have here. We're not anywhere near the 115, but currently at the current reference we're more like 94 degrees, but if we try as best we can to make this a cooler repository, and this probably represents kind of a low point on APD.

We've only gained about 20 degrees C at that level in the repository, we haven't really changed -- the people are concerned about what the temperature at Calico Hills is. We'll always see some temperature down there, we have to live with it. In this case we've seen about 20 degrees, 20 degrees maybe in the uncertainty level.

He's also shown how fast it takes for the rock to heat up above boiling over the years, depending on where you are. Here it takes about 31 years for the rock to heat up between each drift, and he tells me also that that's approximately the same for between waste packages within a drift.

Looking at Tom's work in a little bit more detail, we put this together working with the Livermore people, and Tom looked at it from home recovering, and he agreed with most of those numbers, but basically we looked at his work to date and extracted from it some key temperatures and some key information that we thought you might be interested in, again we can compare with the temperatures here.

I didn't show the 20 kilowatt-per-acre case, I started with 36 and showed some work up to 114. If you go down, this is -- I think Tom said "Gee, I wonder what it would be like if I just doubled the current levels," so that's why he picked 114, just wanted to see what would happen, and we can look at the drift -- this is a drift emplacement case, so he's calculated some temperatures at the drift wall and the waste package wall, and sixty meters below the waste which is close to Eric's fifty and seventy that you saw earlier, and it sort of relates to this temperature here. It's a little bit lower down, so we're well into the Calico Hills here, or ten meters further.

One of the temperatures we see is this one here, 277 degrees. If we said, well, this is similar to this temperature there, 275, so we're pushing that temperature in this case.

Another temperature is sixty meters, which is similar to the 115, and we can see that we're pushing it over in here in the eighty-kilowatt-per-acre case.

If you remember, Tom's was a little cooler than this, but I believe some of the effects that -- I mean Eric's was a little cooler -- some of the effects that Tom is looking at with the condensation and convection and all those he's seeing that possibly there is some more of a heat-up below the repository than what Eric might predict, so he's a little bit higher there.

So if we want to go up in APD we really have to decide whether we could do something about that limit and, of course, if we want to go down then this number is very close to what Eric had, 94 degrees.

Also tried to show what the dry-out might be, because the code that Tom has the capability of doing that. What we really mean here is reduced saturation, it's dried out in that the saturation level is lower than what it would be in an active state which is around 60 to 70 percent saturation, so in each of these cases we've got a situation where it's lower than that number.

We're not saying it's bone dry. As a matter of fact, at this level here this is really getting down to the water table, and he's saying just above the water table there is -- right above it you start seeing some reduced saturation, so it starts impacting the amount of water in the rock just as you start getting up above the water table and keeps going up, so for 1,000 years these are above the waste with quite a large band of reduced saturation. At the current case we're like fifty meters above and below the waste for 1,000 years, and at 5,000 years we're still about in the same situation, it stays dry for a long time according to Tom's predictions.

The last thing we showed here is what the saturation might actually be looking at right inside the drift wall at different times, 1,000, 10,000 and 100,000, and this represents never getting up above boiling, so it stays pretty much where it's at now, and we can see that in this case we'll get back to that situation some time between 10,000 years and 100,000 years in this case, so we'll have a reduced saturation, quite a bit for quite a long period of time even at the 57 case.

I'll turn these off for a second.

That was all I was going to say today on the results of the analysis, and what I'd like to do now is move on into the effects of thermal loading on the engineered barrier system.

At the October meeting we talked about the effects and uncertainties and concerns, benefits, problems, all of those things on the entire repository. We looked at both the engineered barrier system and the natural barrier system, and for this meeting felt that we should focus on the engineered barrier system because we want to be able to understand what might be happening to the engineered barrier.

A lot of the effects can either by near-field or far-field, but how those effects might end up affecting the engineered barrier system, we only have two -- we have a natural barrier and an engineered barrier system, and the thermal loading may affect how the natural barrier behaves, but way out in the far field there may be things happening way out in the far field that might come back and bite us on the engineered barrier system, so that's what I'm focusing on today.

Not that I'm not concerned about the natural barrier system, but since I'm with the EBS and I'm an EBS person my main concern is the EBS.

Now, we have effects on the environment, and we have effects on components. I have to put things, order things in my mind to understand them, and that's the way I like to look at this problem.

When we apply heat, we start out, the mountain is the way it is, and then we excavate the repository, and we've had some effects due to excavation, but at that point we go in and start loading it up and there are things that are happening because we're applying heat that wasn't there before, and that heat will affect the geomechanical, geochemical and hydrological as to how they behave versus how they would have behaved without that heat.

Also, what happens to the environment will come back and may affect how the components perform had that heat not been there, as well as the components themselves are impacted by the heat, so they have their own effects just due to the heat, so components are seeing effects that are a result of this and also the effects of the heat that they have to deal with.

The first one of these effects is the geomechanical, and this involves really the stability of the underground. There are some effects that come back, there's a couple of systems that might affect the hydrology or the geochemistry, but the main thing we're focused on is how the underground structure will survive the heat that's being applied to it.

Now, there's two areas, you've got to deal with the rock mass itself, and also, what it might be doing to fractures. They're sort of related, but I've tried to separate them here so we can talk about them.

We are going to increase stresses due to heat, just due to thermal expansion, and these can be either tensional or compressive stresses, but they are going to change as we apply heat, so we're saying the rock mass modulus and stress will change with temperature and time.

Now, it gets rather complicated depending on the orientation of the excavation, the orientation of the factors and all of those things whether that change is beneficial or detrimental. In some cases it may be one or the other.

The stability of the usable area changes due to those changes in modulus and stress, and compressive stresses may actually increase and will close fractures, and that might make the underground more stable, but also it could reduce stability if it would actually occur that the fractures are -- you know, if the alignment of the fractures and the orientation of the excavation is such that if you get into a situation where you actually make the thing less stable and could get into some joint-slip problems, so we have to look at everything here. It's just very crucial.

The fractures, they could open. In regions of increased tensional stresses you could actually open fractures, and not only tensional stresses but if you were in fact reducing compressive stresses in that area you would tend to open fractures, and if you increased the compressive stresses you would tend to close fractures, so we expect that the fracture permeability will change due to these changes in size, and because of the thermal loading we'll see some changes in how the fractures are going to behave, so we have all of these effects and there's still quite a bit of work and hopefully we'll get underground here soon and we'll be able to study that in situ, but how we're going to resolve the uncertainties of these effects I've summarized here.

We have the SCP which has laid out some pretty detailed scientific plans to address all of these uncertainties, and we're continuing down that path.

Possibly as we do some of these parametric studies at different thermal loading we might adjust these plans and be able to focus on specific questions that we hadn't thought of back when we wrote the SCP, but we are on a path to try to do quite a bit of work in the mountain. We realize that the thermal loads must be incorporated in the design, and we feel that the design can incorporate thermal loading, and up to a certain point we should be able to accommodate it through either adding some structural stability to the underground.

The design methodology that's being developed to understand how the thermal load affects the mountain is really independent of the thermal load, so we're developing that methodology now and it should be useful whether we're in the high or low thermal load, so that's going along pretty well.

We have experience with underground excavations where there is a thermal situation, and we feel that we can use that experience where this would be comparable to the stress magnitudes that we might incur.

Now, in talking to Larry Costin who presented this at the October meeting, he feels that the current level we're at, this is a -- you know, we will have experience available at 57, maybe even 80 kilowatts per acre. If we start getting into the real high thermal loads, real high temperatures, then we might go beyond the available experience here.

Joint slip or fracture propagation will be evaluated through analysis and testing, so this will be part of this testing program.

That's in summary how we plan to resolve the issues with geomechanical.

Moving to on geochemical, two areas -- there are three areas actually that we need to focus on, and that's dissolution precipitation, cation exchange and radiolysis effects.

Most of this occurs when we have wet situations. Depending on what thermal loading we pick it will determine whether we're under an aqueous condition or we're not under an aqueous condition, but given eventually we will be under an aqueous condition you will see: increase in fracture healing with thermal loading increasing, increases in dissolution precipitation and fracture networks; You'll see: changes in silica activities which influence the development of assemblages of different types of minerals in the rock, which will have a tendency to form additional zeolites and clays; will alter the permeability and porosity of the rock; and we have a potential for oxidation, depending on how hot we get, of various mineral phases.

In the cation exchange area we're concerned about sorption. It's not as much of a problem for the EBS as it is for the NBS but, you know, if there are capabilities within the rock to sorb radionuclides even in the near field we would like to capitalize on that, so by raising the temperature we will affect that. However, it's not clear how much and how bad these effects are.

If you remember, that was discussed in October by both Livermore and Los Alamos, Dave Bish, and I believe he made a statement that he thought it would take greater than 100 degrees C for very long periods of time before we got into actually affecting the sorption capability.

Finally, the radiolysis effects will be different in a higher temperature, a different temperature environment as the radiation gets through if we have a thin wall package and the radiation penetrates that package, and whatever the environment is around the package, if it's vapor or water vapor, the results of that radiolysis, the compounds that you get out of that might be different depending on the temperature that we're at. We have to concern ourselves with that.

How we're going to resolve these uncertainties due to those effects is laid out here. Again, we have quite a series of plans in the SCP to deal with these things, and these may be modified as necessary as we go along.

One important thing is making sure that we're integrating between the geochemistry and the hydrology, and there is a working group that is doing that right now. My first viewgraph said "must be integrated," but I was told by one of the members of that group that we are in fact doing that now, so there is a working group between Livermore and Sandia and Los Alamos and possibly even the G.S. that's working to try to integrate those two things.

The elements of the program that need to be resolved as we go through this testing and analysis is the model, how we apply the model, the experiments, rock-water interaction, the kinetic thermodynamic behavior and acquiring data to understand that behavior it's important to use ET36 code and other codes, geochemistry codes. Model development is continuing, and we're also looking at natural analogs. These are all areas that hopefully will reduce those uncertainties.

Lastly for the engineered barrier system is the hydrogeologic, and probably the one that's last but not least.

If we look -- now, this is an area that Tom Buscheck has been doing quite a bit of work in, he's looked at trying to predict the existing situation in the mountain, and basically we're looking at fracture flow and dry-out as we raise the thermal loading, but the current situation is that we do have water moving, we have water vapor moving up in the mountain and it's going up to a certain point and condensing and moving down as liquid. It goes down a little ways, and then gets imbibed within the matrix, and that's going on all the time in the mountain.

As we increase the temperature, that process gets greater. It doesn't increase dramatically, but it does go up with temperature until we get to the boiling point, and then it goes through that phase of boiling, and after it gets beyond the boiling it seems like this process here greatly increases and you get a lot more matrix inhibition that's going on during that phase, and that tends to dry things out a little faster.

We're also going to alter the flow and transport properties of an attenuate factor flow to promote rapid condensate drainage around and below the waste. These here are really -- as we get into the higher thermal loading you'll see those have a greater impact on how the mountain behaves.

We do dry out the rock as we get up in temperature, increase the boiling water transport away from the EBS. As you remember, Tom described that with a lot of viewgraphs and colored slides.

We're increasing the extent of the rock dry-out, and we saw that on the table that I showed you of his results, and we're producing a dry steam environment where we're replacing a wet vapor or maybe even liquid environment for a dry steam environment, and if you look at the temperatures that we're at in that environment we're actually in the super-heat range for an atmospheric pressure and that temperature, so it's truly a dry steam which is described to me as H_2O vapor, or gas really.

A lot of the work that Tom has done has been through modeling using computer programs, et cetera, and we do have to try to validate that work and resolve -- it's left us with a lot of uncertainties, and we have to -- it's very important that we resolve these uncertainties because it might lead to some of the strategies as to how we're going to go ahead, move ahead on this program.

So we do have the site characterization program as mentioned earlier, and that program may be modified as we look at these different thermal loadings and maybe some different testing that we imagined a few years ago to try to look at this process on a wider scale.

But we do have to couple the models, the thermal models to address the thermal load. We do have to look at the hydrologic uncertainties, and the general feeling is that those uncertainties are reduced if you're up above the boiling point because it's the more kinetic activities that are easier to test and demonstrate that they're happening rather than being at a lower temperature, so we felt these uncertainties would be reduced at the higher loading.

Testing at higher temperatures. Conditions provide better experimental basis for model validation. That kind of goes along with that.

Okay. I'll stop here a second and just go back. We've talked about the EBS now, the EBS environment, and basically we've got geomechanical, geochemical and hydrological.

Geomechanical, how is that going to affect the EBS? Well, the stability of the rock is important. If we have either a borehole or drift package, we want to make sure that things don't fall on it, et cetera like that.

The geochemistry is important to the EBS, what happens in the near-field and far-field because when water does come back the composition of that water will depend on the geochemistry, and the temperature will affect that geochemistry, so that's important to the EBS.

And finally the hydrological effects are important, very important to the waste package because that's going to determine really whether the waste package, if it needs to be designed for a completely dry environment or it needs to look at periods of dry and then wet, whether it's hot and cold, et cetera, things like that.

Focusing now on the package or the EBS itself, and if you remember my introductory slides I had the EBS components as the containers, the waste form, and any other components. We haven't gone far enough on looking at alternatives to talk a whole lot about other components, but we will be looking at other things like Dr. Verink stated earlier, the packing material, the backfill materials and how those might help the EBS perform, but today we're focusing more on containers and waste form.

This is a slide that was given at the October meeting by Greg Gdowski of Livermore, and he was trying to show that as the temperature goes up here you have different effects and different degradation loads that you need to concern yourself with, so if we're below boiling we have to concern ourselves with localized corrosion microbio-corrosion, environmental accelerated cracking, aqueous corrosion, hydrogen effects, mineral deposition and radiolysis.

If you can get above the boiling point then you're not in the liquid phase, so your corrosion behaves more as general corrosion, more uniform corrosion, you're not so worried about the localized corrosion where you have several mechanisms here. If you remember some of the prior meetings we had of the board we described all the different types of localized corrosion which we're not having to deal with so much here.

You have some stress-relieving, some long-term aging effects and mineral deposition and radiolysis also is a problem here.

If you were to raise the temperature even further and get up into this range, you might get into some accelerated oxidation which is a real concern of microstructural changes, so it's not recommended that we get up into this range for the temperature of the package itself.

I will talk a little bit about the waste form, and then we'll look at some of the resolutions for both the waste form and the container.

Let's talk about this a little bit more.

Waste form is close to my heart, I've worked with waste form for most of my career. We didn't call them waste forms, we called them fuel, designing fuel for reactors. At the time we weren't designing them to put in a repository, but there are some interesting things we need to look at.

Looking at the glass -- I don't know if this will come up again today, but if we have some questions I think we have probably several experts in the audience that can talk about glass today, but devitrification is a concern. It's a vitrified waste form so we don't want to have to devitrify, so if you keep below 450 degrees C you won't get into that problem, and so it might be well below that.

Under wet conditions, the case where if we were later in time or if we were at low thermal loadings where we went above the boiling point where we would have to deal with water, and if for some reason the waste package would fail and you would get into -- in this case it would take the waste package container to fail and also the canister that the glass is poured, so the pour canister would fail and then you'd see water directly on the glass.

They have run tests simulating that condition, and they find that the vapor hydration rate does increase with temperature, so preferably the glass would like to stay cool if it can if it's going to be exposed to wet conditions.

The same with the spent fuel. If the situation is like I described here with the spent fuel where you fail a container, or if it's a multiple container, and we're looking at robust containers that might include multiple barriers -- if we fail all those and we were to get into the container, and we also started failing the cladding, then the spent fuel pellets would be exposed to a wet condition, and the dissolution of both the pellet and the glass increases with temperature, so again it likes it cool.

Ray Stout at Livermore who is working in this area says if we keep it below 200 degrees C you wouldn't be so concerned with this feature, but this is only on the situation that we fail canisters, so what we're kind of -- what this is telling us is that if we're going to be raising temperatures then we have to make sure we have a canister that will survive, be very robust, because we don't want to fail any of them during that high temperature period, we would rather see them if they are going to fail to be way out there in the thousand to ten-thousand-year time frame where the temperatures are much lower and we don't run into this problem.

The same with the spent fuel oxidation rate. There it doesn't mean wet condition, if it's just exposed to oxygen it will increase with temperature, so this is a case where even if we were at a high thermal loading and for some reason the package would fail, get all the way through the cladding and finally to the pellet, which it would take a major failure -- a pinhole probably wouldn't be a problem, but if we had a major failure of the cladding and the package then the pellet would be exposed to oxygen and that would tend to oxidize the fuel.

They're doing some work at Livermore, some real good work on that looking at UO2, and also at PNL. That will be -- they're looking at spent fuel there -- the found that it oxidizes to U409, and when it takes that phase change it really doesn't change the dissolution rate too much, you know that oxidation change is not a big problem, but if you're oxidized even further to U308 there the pellet sort of turns more into a powder-type form and it's no longer the ceramic robust formula it was in, and if we get into that situation then you would have -- if it would oxidize to that level and then water gets to it you would get quite a bit of dissolution, so we're really concerned about getting up to that point, but again when the temperatures are down that won't be a problem.

The dissolution rate we're talking about here is depending on the environmental history of the waste form, so these are -- again I always need to put myself in perspective, you know, we're not talking about reactors or MRSs and things like that where we have time frames that are closer to our lifetimes, here we're looking at things happening in phases that are hundreds of years long, so if for several hundred years we would have a failed package then whatever environment that waste form is in, pellets or glass, it will be undergoing some changes, and when liquid contacts it later on, that is 5,000 years down the road, how it's going to behave at that point in time will depend on the environment it's been in all of those years prior to that point in time.

Finally in the Zircaloy fuel rod cladding, we talked about that earlier, we're saying that the degradation is reduced if you can keep it within that range, and the 300 degree C, now you know why that's there because we don't want to get into stress/rupture, that sets a higher temperature range.

The 100 degree C is still kind of iffy. This is when we get into the hydride precipitation problem, and it could occur in the 150 degrees temperature range. When you lower the temperature, these hydrides tend to precipitate out, so right now we're saying we'd like to avoid having that happen during the thermal period and try to -- we're looking for a medium-type level there.

Okay. How are we going to resolve these uncertainties?

I think this one -- personally I feel this is probably easier to resolve these uncertainties because we're able to deal with engineered systems that we can take in the lab and test.

I'm covering both the waste form and the container materials here, but we're planning to do some long-term materials testing for the container materials and any other materials that we add to the EBS, and the five-year number that Dr. Verink mentioned earlier is also our goal. We insist that we're going to have to have a minimum of five years of testing on any material, and so we have to get right on this. If we want to maintain schedules, it's quite important that we get that started.

Characterization of post-emplacement waste form behavior will continue. That's been going on for several years both at Argonne and PNL and Livermore, and as you're well aware and I'm well aware since I've been working this part of the program for a number of years we've struggled with budgets and things like that, but we've always tried to maintain the ongoing work, so we've got some samples that have been in testing for several years.

We may not be doing a lot of active work, but at least they're still there under those environments and we can pull them out and check them every so often, so that's continuing, and certainly we'll want to accelerate that work as budgets are available.

Studies will be performed that will consider waste form behavior and containment design in the range of anticipated environment. These studies as we start expanding -- and this is one thing that the workshop did for us in June is we sort of took a broader view of different ways of attacking this problem -- but as we look at different containment designs we might see that we've got some potential out there for some very robust container design. As we look at that, then our reliance on the waste form would not be as heavy.

The SCP describes a performance allocation process, and with the SCP design thin-wall metal container we had to take credit for everything we had to meet the regulations, and even with that we have trouble with Carbon-

14, but everything else we were able to handle pretty well, but that meant taking credit for certain features of the waste form.

Personally I don't think we want to do anything to the waste form to lose any of those features, but it's different to have it there than to try to take credit for it in the licensing arena, so as we look at more robust designs we might be able to have a little easier job of trying to convince the licensing people and the public that we've got a conservative situation here, because these things will always be there to help us even if we're not -- you know, depending on how much credit we take for them.

Finally, you know, we still have some uncertainties going on here, but we're planning a performance and confirmation testing program through retrievability to reduce any remaining uncertainties. Right now that program -- it's called a preclosure program, or load the repository because the repository takes some twenty-plus years to load, so from the time we load the first waste package we'll be watching that waste package and pulling some out, doing some testing all the way through that twenty-plus-year period, and then after that we have to actually go out fifty years from the time we loaded the first waste package, so it's another twenty-five or so years beyond that, so they're looking at fifty years of confirmation testing, and this is when we're going to apply to the NRC to close the repository, and I'm sure a that point in time, well beyond my time period, they will say "Well, we feel that either you have reduced these remaining uncertainties to our satisfaction" or you haven't, and if we haven't we may have to continue doing performance confirmation testing for a longer period.

So we're not putting ourselves in a situation that's irreversible in any case. I would not stand for it, even if I'm not going to be around.

In summary, DOE continues to analyze the range of thermal loadings and is developing thermal management scenarios. These scenarios are going to be used in a study that is going to be described by Peter Gottlieb after I finish here, and they want to look at the impacts on the total waste management system.

In other words, if we were to look at different thermal management, either a cooler or hotter repository, how does that affect the rest of the system, and are these scenarios really doable, because if we want it cooler then we have to either spread things out or age them, so it impacts the entire system, so that study is to address those issues.

And the M&O is responsible for that study, it's being done out of their -- it used to be called Fairfax, I'm not sure if it's still called Fairfax office -- but it's being managed out of the headquarters M&O and will involve a lot of people on the program.

And with that I'd like -- well, we can entertain questions, but Peter will come up and describe that study in more detail.

CHAIRMAN VERINK: We would have time for maybe five minutes' worth of questions if there are some from the board.

MR. McFARLAND: Russ McFarland, a point of clarification.

In the October meeting we had a very interesting history provided on how the thinking of the repositories evolved, and the goals, and if my memory is correct the SCP-CDR in the goals that you listed on Page 3 had as to limit corrosiveness of the canister environment, and the CDR and I believe the SCP state no less than 300 years we would like to see the temperature stay above boiling for no less than 300 years.

MR. MORRISSETTE: Uh-huh.

MR. McFARLAND: The base line configuration, the borehole emplacement tends to reflect that thinking in that aging was not an issue, aging was not required when trying to work with those goals.

Since that period the thinking has changed somewhat, we now and as presented in October the most recent SCP thermal goals are to maximize the time spent above boiling.

Now, if that's the case then aging of fuel becomes a critical consideration. Is the thinking for the design of the MRS, the receiving facility or other pieces of the waste handling system, are they being designed with that thought in mind that aging may be shown to be a very valuable factor in our long-term waste management, and we're addressing it perhaps in the repository, I think --

MR. MORRISSETTE: Right.

MR. McFARLAND: -- but I have yet to hear anybody talk about aging of fuel in terms of MRS or other portions of the system.

MR. MORRISSETTE: Well, that's really the point I was making here, and Peter will be discussing that some, but we need to understand what the impacts are of both high and low thermal loading where aging is required, so in fact, yes, they will be addressing the MRS and its effect.

Matter of fact, they want to get this study done before they go too far down the road on the MRS in case this might affect some of the decisions that they're making on the MRS. Peter will get into that a little bit more.

CHAIRMAN VERINK: Why don't we then start ahead. Peter, would you --

MS. HARRISON-GEISLER: I would like to make just a brief comment.

This is Diane Harrison-Geisler, DOE Echo Mountain Project Office.

I guess I would like to address Russ' comment and restate that we have not changed the SCP approach. We are in the process of evaluating various alternatives, so we are still maintaining the SCP goals.

I think you made a comment that maybe we have changed the reference, and we really have not. We're sticking with the SCP at this time, and have not made any decisions to change any of those numbers.

MR. GOTTLIEB: I'm going to talk to you this morning about a study that has been planned now for several months, and has been coordinated with all of the major participants in the various components of the system, particularly those in the repository, and I will be explaining the organization contacts and the plans for the investigations such as those that were brought up in the earlier question.

I would like to state that this presentation is the work of myself with the considerable support of Bonnie Packer and Bill Bailey who is our supervisor in the systems analysis group at the M&O in northern Virginia.

And just to set the record straight, we did occupy an office building in the city of Fairfax. We're still in Fairfax County, but depending on whether you're talking to the metropolitan area, or the post office or the telephone company we're in Vienna or Falls Church or Dunn Loring. We're right across from the Dunn Loring Metro if anyone would care to come and visit us and take the Metro and not have to bother driving.

Now, the reasons for doing this study are several. In the first place, as you heard in the previous talk there have been a range of thermal management targets proposed for the repository ranging all the way from 114 kilowatts per acre, which could possibly achieve a dry repository for 10,000 years down to 20 kilowatts per acre which would leave the repository below the boiling point of water for the entire time.

These strategies have implications on the rest of the system -- how the fuel will be collected to support the thermal target, how it will be stored, how it will possibly be blended into waste packages, et cetera, and so the selection of the thermal management strategy must reflect this interdependence and an understanding of all these impacts.

Now, to set the context of the study I'd like to show this chart which has the system, the Civilian Radioactive Waste Management System running across the middle of the chart here, with the functions of the system or the components of the system ranging from accept waste, transportation, MRS, and ultimately the repository, and just for completeness we have put in the individual functions or analyses that go on under the repository and repository design.

Now, to fully set the study context we've also included the important external issues -- health and safety, public acceptance, schedule and cost, and we have focused the MGDS or repository part in terms of thermal management strategy which Dick discussed -- the broad range of these strategies were discussed by Dick in his previous talk. I'll leave this slide up as I go through the summary of the objectives and outline of the study.

Now, the study will proceed in a systematic manner, and will start off with identify feasible system scenarios. We have already done a good bit of this work in connection with our throughput study for the entire system, and we will now be focusing on scenarios which achieve certain thermal management targets, and I'll be listing what some of those targets will likely be in a few moments.

Then we will analyze the system level -- The second objective, to analyze the system level impacts of these strategies, and then to identify program-critical milestones, particularly those related to system design, specifications for design, conceptual designs and so on and so forth, and we have done a certain amount of this already which I'll be describing later.

And then for those program-critical milestones we will be providing input, design basis information and so forth, and we're already in the process of doing that.

Now, the study will be conducted in two phases. Phase I, which is the scenario feasibility phase, will be conducted during the rest of this fiscal year, and we'll be also delivering some preliminary results in support of the design milestones for those components which are already underway, particularly the MRS.

Now, I'll briefly summarize the approach to Phase I and then I'll describe that in a little more detail in a few moments.

First of all, of course, a review, a thorough review of prior work. There has been much literature. In addition to the recent studies which Dick covered in his talk there has been considerable literature over the past ten years on thermal management, thermal effects in the repository and so forth.

And then identification of the impacted program decisions, the design milestones and so forth.

Then we will establish the thermal management strategies. These have already been principally identified, and I'll be talking about them in a few minutes.

Define an analysis methodology and the screening criteria to determine whether the scenarios are feasible, and as was alluded before some of these scenarios could entail considerable length of time for storage before placement in a repository. Some others could be very expensive and have other severe system impacts. Those are the things that we'll be addressing in the study.

Then we will be generating the candidate system scenarios, and these system scenarios in addition to talking about the flow of waste through the external or above-ground plumbing system will also relate to the emplacement of waste in the repository, and we'll address the issue of emplacement, disbursed emplacement or selecting emplacement within infilling and the possibility of relocation as well.

These more exotic or sophisticated emplacement schemes would be intended to eliminate the requirement, or reduce the requirement for above-ground storage for the long-term hot scenarios, but I'll talk about that in a few minutes.

Then we will be evaluating individual scenario feasibilities, and most importantly of all presenting options to decision-makers.

This is one of the crucial elements in our approach to both Phase I and Phase II is to try to obtain some sort of closure and try to present the results of these various activities in a manner that is useful to the decision-makers.

Now, the Phase II study approach will be more specifically concerned with impact analysis, and will also incorporate the latest efforts which will be expected in performance assessments to refine the thermal management strategies.

As Dick mentioned in his previous talk, there is considerable effort going on now to refine these analyses of the thermal effect, and of course these will also be impacted by the information developed with the site investigations under the site characterization program.

Then we will use this information to refine system scenarios and establish measures of effectiveness, further evaluation criteria so that by late FY '93 we can make more definitive proposals for the decision-makers.

Now, I will speak in more detail on the Phase I study approach, and to set that in the proper context I will also put up a flow chart and I will mention the items on the flow chart, I will explain the flow chart as I go through the text here.

First of all, we establish four thermal management strategies. Now, these were selected to represent the range of the suggestions that have been made by the study so far.

There will be some possible variations as we go along, but that will probably not occur until Phase II.

First of all is the long-term hot scenario, and it's only -- these are not listed in any particular order of preference, but this is sort of a sequence with decreasing temperatures.

The long-term hot temperature, the long-term hot scenario is proposed to keep the repository above the boiling point for 10,000 years. This is as Dick pointed out in his talk approximately equivalent to the peak heating scenario from the Livermore analysis, and corresponds to 114 kilowatts per acre, which just represents the highest figure that has been analyzed so far, and does not represent a refinement of this particular target, which we expect as I said to be refined during the coming year, and we will at that time incorporate whatever that refinement is.

Then we have two intermediate scenarios which are really quite similar. The SCP scenario specifies 57 kilowatts per acre, and there was a target -- there was no specific thermal target, but the conclusion was that the repository would be above the boiling point for something between 300 and 1,000 years.

The SCP analysis was done with ten-year-old fuel, and an average fuel age of thirty years seems more realistic at the present time, and so we split this into two pieces, one which would simply follow out the SCP emplacement strategy, and the other which would have a thermal target and have a somewhat higher APD loading in order to achieve that thermal target.

And then the scenario which is characterized as cold, which of course as Dick has pointed out is not cold because nothing can be cold if we're putting waste in the ground, but does keep the repository below boiling.

Now, these thermal management strategies are then used to drive the system scenario generation, and in order to support that we will have a methodology for organizing the parameters of those scenarios which will principally be the emplacement parameters like the area power density and the potential for changing operations, moving the waste around and so forth, and then waste acceptance consistent with available spent fuel, so when we generate the scenarios we know that there is the waste available to support them.

And then following from that we will generate the candidate system scenarios which will include these elements, and just to point out there is the emplacement methodology which deals with the repository underground, the waste acceptance strategy, the possible MRS modes of operation, and the question of blending which could take place at the MRS or the repository, and the problem of extended storage which could also take place at the MRS or the repository or somewhere else.

Then we will evaluate these system scenarios, and the evaluation is illustrated on this flow chart by these vertical lines which indicate the assessment of the parameters resulting from the simulation or modeling of these waste movements.

As part of our system throughput study, we have put together a number of existing computer programs to track the waste movement from initial acceptance at the reactor through placement in a repository, and we can then see what the statistics and impacts are on the individual components here, particularly the MRS and transportation through these programs and take this information, digest it into a set of parameters to characterize the system behavior, and then to evaluate the scenario feasibility.

And of course the last item, as I mentioned previously to organize the analyses into a format that can be presented to the decision-makers. First of all, we will have inputs to Phase II of the study, then to the CRWMS management, and to program requirements and design, and I'll discuss some of those in a minute, and then to other program areas.

Now, just to illustrate or to explain all the participants in the study, we have prepared this chart showing what the communication links are, and we have of course OCRWM which has been supporting and sponsoring this study and directly managing it through the M&O in northern Virginia.

The parts of the system which are most strongly represented here are of course systems analysis which is managing the study, and waste acceptance and transportation.

Now, M&O in Charlotte is responsible for the MRS design; M&O in Las Vegas the subsurface design, weight package, performance assessment, site characterization and system integration.

Now, we are also in contact with the groups that have been doing the extensive repository thermal analysis at Livermore and at Sandia, and both these groups have reviewed all of the preliminary documentation and technical information that we have been generating so far in this study, and so we can say that it is a fairly coordinated effort at the present time.

Now, to give you some flavor of the program and design impact that we are expecting to address, we have here a list of the potential major system issues organized by the system component.

First of all, for waste acceptance we will be looking at the potential for fuel selection according to fuel characteristics rather than allocation rights.

Now, we are certainly aware that the existing contract specifies only allocation rights and the utilities have the option, or there is some flexibility as to the actual age of the fuel that will be picked up, allocation rights being specified now as oldest fuel first.

So it is likely that some of the first few reactors to be picked up will be oldest fuel, and then it is possible that others will be younger fuel. We will be looking at benefits to be derived from some selection, fuel selection strategies which are aimed at specific ages of fuel, recognizing of course that that's not supported by the present contract or laws, but also recognizing that if the potential benefits are significant then incentives could be arranged and there could be other things done to develop a selection policy.

So this is expected to be some kind of -- this is expected to be useful for any exercises or any decisions that might be made to try to change those policies.

Then of course there is a host of MGDS requirements that we need to consider. First of all is fuel blending. The simplest MRS design will not support a significant amount of fuel blending, but there are possible extensions to the MRS design which are under some degree of consideration, and we will be addressing those.

Further to support fuel blending is the question of selective withdrawal from long or short-term inventory.

There is also still the question of consolidation.

Extended storage duration certainly would be required for the cold strategy, and possibly for the long-term hot strategy.

And then there is the question of storage capacity which is presently limited to 15,000 tons by the current law, but could conceivably be changed.

Now, there is an even longer list here of MGDS requirements which are involved. Now, the principal activities of our study are going to be focused on design concerns for the nonrepository portion of the system. The repository exercises are ongoing independently of this study, but all of these issues need to be addressed and understood within the context of our study, and that will be the principal role that we will be playing in the MGDS analysis and design process.

As you can see, we have listed here the crucial question that is now being examined of emplacement, sequence and relocation, but also the possibility of a significant lag storage, spacing between packages, climate control, roof stability, retrievability -- these are all things which are significantly impacted by the temperature in the repository which is an important part of the thermal management strategy.

And then there will be other potential system impact issues such as the disposition of retrieved waste and the use of dual-purpose or universal casks.

Now, these last issues have been studied before in the past and found to be much more expensive than the base-line or SCP design at present. However, with many of the siting concerns that have are now being, or siting alternatives that are now being considered for the MRS the minimization of handling of fuel assemblies may become an important parameter which will give some additional benefit to concepts such as these, and of course this kind of concept is already being considered for some of the MRS proposed sites.

Now, to give you some of the flavor and the conditions of the study, we have here the assumptions for generating our initial set of scenarios which we'll start off with, and then I will show slides showing some of the variations that we expect to do on this initial set of scenarios.

First of all, the assumptions that will be used for all the scenarios, a single repository which will store 63,000 MTU of spent fuel and the equivalent of 7,000 MTU of high level waste which is loosely called a 70,000-MTU repository, although this 7,000 equivalent is not 7,000 tons of material.

Then we will follow the present guidelines and regulations on the MRS with a 10,000-ton limit before repositories start up, and a 15,000-ton limit thereafter, and a forty-year license period.

Now, I should state that the nominal scenarios now, the nominal system scenarios now which take the waste through this chain generally have MRS activities which are much less than forty years.

Obviously if we wanted to store some fuel in the MRS for more extended periods of time we would bump into this licensing period requirement which could be increased perhaps if necessary.

Now, the next set of assumptions will be the most frequently used prior assumptions which correspond roughly to the SCP that all waste packaging will be done at the MGDS and a thin-walled waste package with a vertical borehole emplacement and first emplacement in 2010. Now, most of the scenarios we consider will relax these constraints, and I'll show those now.

In order to look at more robust waste packages and varying emplacement sequence or relocation we will be seriously considering drift emplacement, and there has been considerable work investigating these alternatives thus far principally at the M&O office in Las Vegas, and Hugh Benton is here, he has been responsible -- Hugh Benton who has been responsible for the studies over the past several months is here and will be able to answer questions about this if necessary.

Then as I mentioned before we will relax some of the MRS constraints, expanded inventory, extended period of operation and selected withdrawal of spent fuel, and then we will look at alternatives for waste acceptance which will range from a fairly old type of fuel which would be priorities for reactors requiring no dry storage, requiring new dry storage so that we could minimize the capital investment required at the reactors for new dry storage ranging to the other extreme selecting youngest fuel over some number of years of age where that number would have to be greater than or equal to five.

Now, the Phase I study output follows directly from what I have already spoken about in terms of the approach, but just to list it here for you we will have a set of system scenarios which will be feasible according to our feasibility criteria and will support the thermal management strategies.

Now, if it turns out that the initially proposed system scenarios when we run them through our computer programs and do the analysis of the emplacement that results, it's conceivable that these scenarios may turn out to be unfeasible by our criteria, in which case some of their parameters may be adjusted, or we may try some new scenarios, so there is a potential feedback from here to here, but I didn't want to put that on the chart because this is not really an iterative study to come up with some optimum at this point in time. We might at some future date do that, but now we hope and expect that most of the scenarios we generate initially will be found to be feasible and be able to be reported for these purposes.

We will also provide the impact data, although this impact data will be refined in Phase II, and information to support program requirements as I said, particularly the MRS system specification which is coming up in July or perhaps a few months following, and transportation cask procurements which are coming up shortly also.

And then we also will have as a steady output the plans for Phase II of the study, and of course that will be reviewed by all the program participants and scheduled again to meet specific program milestones.

Now, the Phase II study approach is not as detailed because part of the Phase I study output is a plan for Phase II, but we have a flow chart similar in nature to the flow chart for Phase I but conveying a little different message, so I will go through these two in parallel.

First of all, as I said we will use the refined or additional performance assessment and licensability studies to refine the relation between emplacement parameters and the behavior of the repository, the hydrology, the thermal behavior and the mechanical behavior, which are critical elements in this overall MGDS analysis.

So we will take the scenarios, the system scenarios that we have from Phase I and utilize the refined capabilities of the MGDS analysis to come up with refined thermal scenarios, and possibly refine the system scenarios in response to the refined thermal scenarios so that the system or the thermal management strategy -- so that the system scenarios will be sure to support the thermal management strategies so that the waste acceptance, storage and emplacement will meet the thermal targets that are established, and so those refinements are listed here.

The other thing I want to point out about this chart is that these two lines of activity proceed somewhat in parallel, this being principally the repository analysis which will be ongoing at M&O Las Vegas, at LLL, and in Sandia as well, this being one chain of activity, and then the evaluation of the system scenarios and the analysis of tradeoffs which will be ongoing and refined to reflect these results.

And this just continues the explanation of the remaining items on this chart. First of all, the evaluation criteria which we'll consider in addition to cost, operational complexity and schedule, and then incorporate measures of external impact which are the health and safety and public acceptance, so that when this process here is fully defined we should be incorporating to the maximum extent feasible and appropriate all of the relevant considerations and questions, issues, et cetera, which people are concerned about for this system.

And then finally we will propose alternative options for the decision-makers and provide further input to the design activities.

And the preliminary plans for the final output of this study are first of all a preferred implementation scenario for each thermal management strategy, so that of the several scenarios that we will start with to support each strategy we will have one preferred implementation scenario.

For example, for the long-term hot scenario we will have something that will specify the length of time to be stored above ground, the possible sequential emplacement and possible relocation in order to avoid lengthy above-ground storage and so forth, but that will be -- whatever that turns out to be that will be a preferred implementation strategy.

Then based on all of these criteria for this implementation scenario we will be able to compare the thermal management strategy. In other words, at this point we will have arrived at a preferred scenario, preferred system scenario to support each of the thermal management strategies, and then we will be able to compare the thermal management strategies on the basis of the impact of each of those particular system scenarios with respect to all of these critical issues from health and safety to site suitability.

And then the use we expect to make of these results with respect to parameters that will be useful for determining program requirements and for inputs into design activities will be throughput rates, receipt rates at the MRS, shipping rates from the MRS, and receipt rates at the repository, and then of course the proposing of alternatives to the decision-makers, but with the alternatives having considerable analysis and information to facilitate the actual decision.

That is the end of my prepared material, so I can answer questions now.

CHAIRMAN VERINK: There will be time for one or two questions. Anybody on the board?

Yes, Russ.

MR. McFARLAND: Russ McFarland.

Could you give us some indication of the schedule of the Phase I and Phase II? You mentioned FY '92 and '93, but could you give us a little closer indication?

MR. GOTTLIEB: We expect to have some preliminary results by July of this year. Those as I mentioned before will be particularly critical for the MRS design.

We would expect to start Phase II by October, possibly sooner. We would expect to have these kinds of results from Phase II by July of '93, possibly -- well, we would have some results earlier in '93, we would have the final results some time between July and September.

MR. McFARLAND: One other question.

You haven't mentioned the ESF, the ongoing design of ESF. Are you concerned that decisions may be made in the design of that that could impact the recommended configuration for the repository?

MR. GOTTLIEB: We have not looked at that issue separately from the overall repository problem, but we will be aware of it, and if it looks like there is a divergence then we will try to identify that and deal with it.

MR. McFARLAND: Thank you.

DR. PARRY: Jack Parry.

I was wondering what level of support does this involve? How many FTEs, dollars?

MR. GOTTLIEB: If you look at the core group in systems analysis it will probably be something between three and five FTEs.

There are the additional groups that I mentioned that we will be coordinating with, and it's hard to specify exactly what their involvement will be because much of their involvement -- it's hard to identify their involvement particularly devoted to this study because these will mostly be ongoing activities that they will have anyway, but I would estimate maybe another two or three total FTEs.

CHAIRMAN VERINK: Dr. Deere.

DR. DEERE: Yes.

What concerns me a little bit, and I'm sure it probably concerns you, is that your date for finishing this is still at a time where we'll have very limited actual site data, this has been our concern from the very beginning, and so it's going to be a little difficult to have definitive results from a Phase II study without having definitive input on the site.

MR. GOTTLIEB: What we expect to have by the end of this time is in addition to the analysis, the specific analysis and impact, we will have a methodology which will permit the refinement of these tradeoffs in the future according to additional input from the site investigations and so on and so forth.

However, we expect those to be refinements. If it appears at this time that there are major uncertainties that could affect decisions one way or another then we will identify those, and perhaps we will -- I would say we will try to identify these things earlier than the end of the study and perhaps make recommendations as to investigations that are necessary. We will be at all times aware of this uncertainty.

DR. DEERE: Thank you.

CHAIRMAN VERINK: Thank you very much.

I think at this time we're right on schedule, and let's take a ten-minute break until eleven-ten.

(A brief recess.)

CHAIRMAN VERINK: We have twenty minutes allocated, or it actually would be about 16 minutes allocated for questions at this time having to do with thermal loading. Does anyone from the board or the staff have a question?

Dennis.

DR. PRICE: My first question is have we ruled out blending at the utility?

CHAIRMAN VERINK: Does anyone have a comment on the matter of blending of fuel at the utility has been ruled out?

MR. BAILEY: We have not ruled it out at all. We're including that as a possibility.

DR. PRICE: Okay. I noticed in the presentation they mentioned blending at the MRS and the MGDS only and didn't mention the potential at the utility.

In one of the presentations there was a discussion about the effects of radiolysis and steam dry-out and composition of water and so forth, and of concern is the relationship or the interrelationship among parameters such as this and the type of container, and if we had a thin-wall container, a universal container, and then we have this military container, military waste container, and some of these may be limiting factors, that is one of the containers may be a limiting factor as compared to the others, and if you consider for example the effect of radiolysis and you've got a self-shielded robust container then maybe that thing, that particular parameter, its importance is greatly diminished, or how do these interact, and to what extent on the alternatives of the containers are we really going to get into and massage these particular things that we hold out to be important such as dry-out and composition of water and so forth?

CHAIRMAN VERINK: Dick, maybe you've got a comment on that.

MR. MORRISSETTE: Dick Morrissette from SAIC.

Dennis raised some questions as to how we're to interact. As we look at alternative designs for the waste package and EBS, these alternative designs will affect some of the uncertainties and affects I discussed earlier.

I believe we will have to look at all those things as we look at different alternatives. We're just starting to look at some of those alternatives now, we're limited in our resources right now and we haven't been able to get into that in much detail, but we're sure as we go through each one we will be able to put less emphasis on certain effects as other effects, and that will all have to be integrated in that process.

Maybe somebody else would like to add some specific responses, be it from Livermore or the M&O, on that.

CHAIRMAN VERINK: I wonder if Peter or if somebody from Livermore would have a comment?

DR. BLINK: I'm Jim Blink, Lawrence-Livermore Lab.

Livermore and the M&O are both looking at many of these factors for the various designs that are under consideration.

The M&O right now is pursuing the drift wall, the self-shielded design, and are looking at some of these concepts.

Livermore is continuing to look at the radiolysis, although at a very low level of effort due to budget constraints.

CHAIRMAN VERINK: Is there any sort of a time schedule that this is going on?

DR. BLINK: I really would want to leave it up to DOE to lay out the long-term time schedule for the R&D. We only really have our budgets for the next couple of years.

CHAIRMAN VERINK: Yes.

DR. PRICE: Another question then is there were a number of statements made about, for example vapor hydration increases with temperature, oxidation increases and so forth. How -- I didn't get a very good feel for how important this is ultimately for the criteria. What difference does it make that these increase?

And I know we're dealing with some failure in containment and so forth, and how remote are we getting to the point that these really -- how unlikely is it that these will ever become important considerations?

MR. MORRISSETTE: Dick Morrissette from SAIC.

If we go back to the SCP days, or the days when the 10 CFR 60 was laid out, they had identified a period of 300 to 600 years where they wanted to maintain substantially complete containment, and I believe the basis for that was because that was during the high thermal period, and they understood even back then that the waste form itself preferred to be at lower temperatures than higher temperatures, so if it was going to be exposed to various environments they preferred to have the container substantially complete, in other words designed for 100 percent or 0 percent failures to get them through that period, and within the container of course we can control the environment so that the temperature doesn't necessarily impact the waste form.

Beyond that 300 to 1,000-year period the regulation was written so that the -- this is a 1,000 to 10,000-year period where they would put less reliance on the container and more reliance on the waste form, so I believe some of these degradation modes that we're concerned about the waste form will impact in a situation where we would have containers designed for about the 1,000-year period, we would not want to have an increased vapor hydration and dissolution and so forth, oxidation, et cetera, because during the thousand to 10,000-year period we wouldn't be able to meet the regulations as stated now, which is one part in 100,000 release rate from the waste form itself.

We're looking at -- thinking it's changed we're looking at extended life, we're looking at robust containers, and we're also looking at hotter repositories, so how those all work together will be a little different than what we're thinking back in SCP, and we need to do studies to trade those things off.

CHAIRMAN VERINK: The NRC of course has given an opinion about the thousand-year thing, and that should impact this question considerably.

MR. MORRISSETTE: Right, and they've indicated that we can take credit for containment if we can show that it's going to last longer than the thousand years.

DR. PRICE: Another question, and this is rather specific, but in your presentation, Dick, you mentioned that when you're going through repository scenarios that the universal cask reduced the number of containers down to seven thousand, but that the M&O is looking at this differently. Could you explain that statement?

MR. MORRISSETTE: I didn't want you to put 7,000 and, you know, freeze in your mind because we are looking at different designs there which will change that number. I believe Hugh might want to address that a little bit and see what the latest thinking is on that one.

MR. BENTON: I am Hugh Benton with B&W Fuel Company, and part of the M&O team in Las Vegas.

We are looking at a wide variety of possibilities, concepts. As you know, we are not yet to the point of advanced conceptual design, we are still in the pre-advanced conceptual design stage.

The number of containers will vary with how much we can put in each, and we're not yet to the point where we can decide how many fuel assemblies can go in each canister. The number 7,000 is a reasonable estimate of some number around which advanced conceptual designs might be made in a more robust container.

We are proceeding toward the idea of putting as many assemblies in each container as we can, assuring safety.

If I may, sir, I should also address the question of the schedule.

We have generally proposed to the DOE a schedule which would allow us to focus in on the advanced conceptual designs that we ought to work on during the ACD phase which is scheduled to start in October of '92, so we want to determine which advanced conceptual designs should be worked on between now and then, and then proceed into ACD.

As you know, our primary concern is that we start the long-term material testing that is going to be necessary before we can achieve a license application, and we have stated to the DOE that if that testing can proceed not later than early in Fiscal Year '94 we believe that we can recover the schedule slippage which has occurred during the past few years.

DR. PRICE: A question about the 1998 MRS goal. It seems like that's a goal tied to the MRS, although I believe the regulation is the start of operations, is it not? Isn't that the way the regulation reads, the start of operations rather than receipt of fuel?

CHAIRMAN VERINK: That's the first receipt of fuel for the MRS.

MR. MORRISSETTE: Dick Morrissette, SAIC.

I believe DOE's contracts read that they would start receiving fuel in January 1998.

DR. PRICE: Is it receipt of fuel, or start of operations?

MR. GOMBERG: I understand it's receipt of fuel.

DR. PRICE: So the MRS date then in most everybody's mind is 1998, that's the pillar you've got to kind of build on. To what extent is that -- you mentioned you're not really doing an iterative study and are going for optimization. Is that being driven by the 1998 date?

CHAIRMAN VERINK: Can you repeat?

DR. PRICE: Yes.

The statement was made that the studies were not iterative and it wasn't really going for an optimum decision. Is that consideration being driven by the 1998 date which sits out there that we have to have for the MRS, and the MRS composition and design may not be completely an optimum design for an optimum system, maybe even will tend to fix the repository considerations to some extent because that 1998 date is one you've got to meet.

MR. GOTTLIEB: That is not the guiding constraint in the study.

The reason that I do not want to emphasize iteration and optimization is because of the nature of the analysis that we'll be doing is more to identify impacts of rather straightforward scenarios.

However, it is not thought at the present time that the 1998 start-up is in any way constraining as far as options that the MRS is concerned with. If it turns out over the next year that that looks like it is a serious constraint, then we will identify it that way. We will raise that concern. It does not appear to be at the present time.

DR. PRICE: But at the present time you are proceeding on the Phase I procurement of casks which sets the type of casks that will be handled at the MRS and really starts fixing the MRS design.

MR. GOTTLIEB: Well, that does to some extent, those will be the casks handled initially. There are options that we are analyzing right now that consider phasing in other types of casks at later stages of the program.

In other words, we recognize that certain decisions will have to be made with respect to an initial configuration of the MRS and the transportation system, but we also are looking at possible changes downstream from those.

DR. PRICE: But those changes may become more expensive than if you could make them upstream?

MR. GOTTLIEB: That is correct, and we will identify that as such.

CHAIRMAN VERINK: I think there's another comment on this point; is that right?

MR. GODMAN: My name is Ray Godman, I'm with the M&O.

A comment on a couple of things. The Phase I cask procurement is viewed as an interim activity in any case, whatever the optimum or steady-state program or system turns out to be, is such viewed as a short-term interim activity using available and off-the-shelf transportation casks that would not be a part of either a storage mechanism at the MRS or the repository.

So I think that the cost issue with respect to that is not something that would be constraining with respect to some different system concept if it turned out to be the desired one.

Secondly, at the MRS we are proceeding with a conceptual design using a design basis that would allow for modular storage technology which is not the optimum choice if you're going to do a lot of tailoring at the MRS of fuel shipments to the repository, but would allow for some tailoring, and then we're doing variations on that design to assess the cost and schedule impacts of variations that would allow for a lot of tailoring of fuel shipments to the repository, or none, so I think we're trying to take both of those factors into consideration.

It's hard at this stage I think for us to really think in terms of some sort of universal cask design when we're at such a preliminary stage in understanding the repository itself and what would be required for a really long-life container to put in the repository.

CHAIRMAN VERINK: I think we'll have to call the questions off now at this stage, and the next item on the agenda --

DR. DEERE: Ellis, can I just add one piece? I'm sorry. I was a little late getting down.

I wanted to go back for a moment to the geomechanical effects of the thermal loading, and there are a number of studies ongoing, and we saw that the opening of fractures and changes in the stress levels are important, but I think that these present types of problems that are rather easily handled within the state-of-the-art of supportive tunnels under dynamic loading or even under deep static loading, that all we have to do is know there's going to have to be probably fiber reinforced shotcrete and a goodly pattern of rock bolts, so I believe it's not of the same category of uncertainty that maybe some of the other things are that were presented in the geochemical lines and others.

Now, to give an example, at the meeting about two and a half weeks ago in Irvine, California that we had on the seismic loading, there a presentation was made of the dynamic effects on a tunnel that was 500 meters from a nuclear explosion, and in this tunnel which was going to be hit broadside by the effects of the nuclear detonation they had very heavily instrumented, but the support that they used was just a little bit more than their normal tunnel support.

As an example, during construction they used two-meter-long rock bolts, and when they got through they then hardened the tunnel in their parlance, and the hardening of the tunnel was done by simply putting in four-meter-long rock bolts, and this time in the floor as well as the sides and the top, and then having I believe five or six centimeters of fiber-reinforced shotcrete, and we saw the high-speed movie that was taken inside, and when that wave hit from the side you could just see the cracks starting to open and pieces of shotcrete coming off, but the surprising thing was this tunnel moved thirty centimeters in response to the load, and came back fifteen, and suffered an acceleration of 28 Gs and particle velocity not of two inches per second which they considered most buildings can handle, but three meters per second, and when they get all through you had a couple little cracks left, a few little pieces of shotcrete on the floor, nothing bigger than a golf ball, and a completely stable tunnel, so all it really took was a uniform degree of support that was just a little bit more than the normal, and I think that everyone who witnessed those pictures and saw the instrumented results were really quite impressed that seismic disturbances as well as nuclear disturbances can be relatively easily handled, and I feel this is exactly the case we have with the thermal loading, and nothing with near the increase that we're going to get with dynamic effects from a nearby earthquake, for instance, that the thermal loading is something that has to be looked at, has to be designed, but it's really not a big -- it's not going to be site suitability yes or no, it's not going to affect the design. It's going to be we simply cannot have a design with a lot of open spans that are not carefully supported, so I'd like to put that in context, and the way we look at it with other questions that still have to be looked at very closely both in the laboratory and in the field.

Thank you.

CHAIRMAN VERINK: Thank you very much, Dr. Deere.

MR. VOGLE: Can I respond to Dr. Deere's comments? This is Mike Vogle, SAIC.

I agree wholeheartedly with the observations with respect to stability of the excavations. I believe we have some concerns, however, about the fracturing of the rock mass which basically is a transition between the geomechanical effects and the hydrologic effects, and I think our biggest concern with geomechanics is whether or not we're going to create new fractures and whether those fractures will have any bearing on the hydrologic performance of the site.

With stability I don't believe we have a concern, but I think we have some questions about fracturing, opening existing fractures.

DR. DEERE: Yes. I won't argue that question, except I really wonder if it's going to be very important, because we're going to have a lot of permeability anyway with the open tunnel. If you have a little bit more permeability with cracks, is it that much different.

MR. VOGLE: If it's time to put the professional reputations on the line, I agree with you, I do not believe this to be a problem, but I think we have to convince the NRC that it's not a problem.

DR. DEERE: Thank you.

CHAIRMAN VERINK: Thank you very much.

Now I think we should get back on the agenda, and Ken Chacey of the DOE Office of Environmental Restoration and Waste Management is our next speaker.

Ken.

MR. CHACEY: While we're getting reorganized up here, I'd like to say it's a real opportunity, Dr. Deere and the rest of the members of the Technical Review Board, to have an opportunity to exchange information with you.

With the timing of the repository and the start-up of the vitrification facilities we feel that our interface with the Office of Civilian Radioactive Waste Management and its oversight groups, whether or not it's the ACNW or whether or not it's the TRB is very critical to our start-up information and the basis for reasonable assurance that our waste form will be acceptable for disposal in a repository.

What we want to do, and what I will do here very briefly is discuss the program that we have laid out here for you for the rest of the morning and the remainder of the afternoon, and then discuss some logistics associated with tomorrow's tour, and then very briefly go over some of the organizational activities that we have at headquarters and how we have streamlined and expanded operations to support the waste management program.

In terms of the agenda, Clyde Terrell who is the High-Level Waste Division Director, he's the Defense Waste Processing Facility Project Manager, will give an overview of the Defense Waste Processing Facility and the Savannah

River operations. He is a DOE employee and works down at S Area where you will be going tomorrow.

Bill Pearson works for Clyde. He will be discussing waste acceptance activities in a broad overview standpoint with concentration on quality assurance.

And we have Sharon Marra and John Plodinec that will be discussing the waste acceptance testing program.

Norm Boyter is the Vice President and General Manager for the Westinghouse side and counterpart to Lynn Shostrum, and he's sitting in the audience out here and is available also to answer questions and participate as appropriate.

At this point I'd like to just briefly describe how we're organized at headquarters. Leo Duffy was recently appointed an assistant secretary and confirmed by Congress as the Office of Environmental Restoration Management Program Director. Underneath him we have five organizations that support him.

Jim Dieckhoner acts as the EM-10 organization and support him from an administrative and programmatic function.

Randy Scott covers the quality assurance aspect of Leo Duffy's program, and this is an important interface with us and with the RW, the quality assurance program being run by Don Horton under RW-3.

The Office of Civilian Radioactive Waste Management Office of Waste Management Program under Jill Lytle is where we are located on the far left-hand side of the chart, and we have two groups that support the work that's being done under Leo from the environmental restoration standpoint which is Pat Whitfield, and also from the technology development under Clyde Frank.

The regional operations office is shown on this chart because Leo also is the program secretarial officer for that site.

Since about 1979 this group up at headquarters has grown from approximately 45 people in 1979 to maybe fifty people by 1989, and then up to 250 in 1992, so there's been a lot of activity going on to try to support the field office needs and to get FTEs to support activities not only at headquarters but out in the field associated with this program.

I had mentioned that Jill Lytle is the Deputy Assistant Secretary for the Office of Waste Management, and underneath her there are four or five groups of which we belong in the Office of Waste Management under Mark Frei, and Mark Frei handles the WIT program which I believe that TRB is aware of, and with the recent court decisions we certainly have our hands full in trying to move that program forward, and underneath Mark he also handles the vitrification projects which is where I work, and we have three vitrification projects that we're working on right now.

The first one and the one that is off the chute first is the Savannah River Defense Waste Processing Facility.

The next facility that's scheduled to start up operations is the West Valley Demonstration Project located in West Valley.

And then the third that's going to design, construction and system review right now is the Hanford site out at Hanford.

We're also working and integrating these activities with the program to support the high-level waste long-term disposal plans out at Idaho.

So that gives a very brief description of how we're organized at headquarters in order to support the program down here at the Defense Waste Processing Facility, and again I think it's important to note at this point that we have been working with the Office of Civilian Radioactive Waste Management in a number of areas.

One of them is the review of important documents that support the licensing data base for the repository program, and the second is to interface with them on quality assurance activities, of which we have recently negotiated an MOU to work with them directly with our program and my group to support a direct interface there in terms of the quality assurance requirements.

Again, we appreciate this opportunity to have the board down and have them interface and look at some of the things that are going on at a production facility and to see the construction site in its stage, and to get some information on where the testing programs are at in that regard.

At this point I'd like to have Clyde come up and give an overview of the Savannah River Program.

MR. TERRELL: Good morning.

The first thing I'd like to do is welcome all the visitors to what Peter has called the Central Savannah River Area, CSRA. You'll hear that maybe from time to time on the local news.

More specifically on behalf of the Savannah River Field Office I'd like to welcome you to the area and to our site.

If you look at it on a map of the state of South Carolina it takes up a chunk of that, it's about 300 square miles, 192,000 acres. You can see all of the area colored in green on this map depicts the borders of the site, it's almost twenty miles across.

The waste management areas that we're particularly interested in are almost right in the center, from F Area where there are tank farms that collect high-level waste from separations activities, and sister facilities in H Area that do the same thing, the burial ground is in between the two. S Area is where the defense waste processing facility is, and Z Area houses a saltstone facility.

The mission of the site as we see it today is to continue production of tritium. We also refurbish some of the limited-life components for weapons systems.

The management of the nuclear waste, that's the thing that I'm most concerned in, and there is some recycling of scrap plutonium. Historically of course there's been a lot of production of plutonium 238 and 239.

I want to stop that part now and get to the package that you have, I see people looking, and those were just some general sides.

This you will actually find in your packages, and that is a mission statement for waste management, and that is to provide safe and environmentally sound handling, storage, treatment and/or disposal of radioactive, hazardous and mixed wastes generated at the Savannah River Site.

The next slide you have is a replay of the map so that you can be aware of where these things are.

If I focus in to the center of that map we can see existing facilities that are bordered in black, new facilities that are cross-hatched, and planned facilities that are solid black. Solid is the burial ground expansion, and the hazardous mixed waste disposal facility.

Of course I mentioned earlier that we had a tank farm in F Area that collects high-level waste from separations activities.

One thing that shows on here is seepage basins here and here, and these seepage basins are no longer in use.

The retention basin at F Area collects runoff, just rain water runoff, and it's sampled before it's released to any streams, the streams on site.

Things that are showing up over here, this Beta-Gamma incinerator is no longer operational, it's being decommissioned. It never really went operational.

And the transuranic waste facility is planned. There is an effluent treatment facility which is a final processing state for streams that may have at one time contained some trace radioactivity, and this is a final verification clean-up before releasing them to the streams on site.

Then the Defense Waste Processing Facility is here, saltstone again is there, and one more that's showing up is a consolidated incinerator facility at the planned facility, and it would have a predominantly organic waste produced from the Defense Waste Processing Facility.

In performing the mission over the years we see from the site that it's been a really interesting thing to study and look at. It's pretty much a closed process, bringing in raw materials up front, producing the fuel and the targets that then go into the reactors to give us the desired products, those irradiated tubes and targets are stored temporarily at least in storage basins at the reactors.

The tritium targets then go to the tritium facilities for extraction, with the fuel and the plutonium targets going through the separation processes for extraction of the other materials.

High-level waste resulting from the separations process has gone to tank storage facilities in waste management facilities, and then we finally will close that loop going to the Defense Waste Processing Facility.

The waste all along through the process has typically been classified by about five different groups. We have the low-level radioactive waste which is the bulk of the waste; intermediate-level waste, somewhat more radioactive and contains a little more Alpha; transuranic waste; the mixed waste; and certainly there is the high-level waste.

To put those in a better perspective, low-level waste on site that has been defined as that waste that has Beta-Gamma activity less than 300 millirems per hour, less than 10 nanocuries per gram Alpha is the bulk of the waste generated, and historically has approached a million cubic feet per year.

Examples of this are the protective clothing that's been discarded because it can't be washed or decontaminated any more, hand tools, construction debris, soils that have been contaminated, and the other miscellaneous low-level wastes that I'm sure most of you are familiar with.

Intermediate-level wastes as I said are slightly more radioactive. They have Beta-Gamma activity in excess of 300 millirems per hour. Alpha activity now has to still be less than 100 nanocuries per gram, and it includes the tritium crucibles from tritium extractions, separations process, equipment and reactor scrap materials, and so forth, and it approached 75,000 cubic feet per year on an historical basis.

The mixed wastes, a much lower generation rate, around 20,000 cubic feet per year, and this is where we end up with tritiated oils, mercuries, scintillation solutions, contaminated lead and cadmium and process equipment.

The transuranic waste is that waste that's over 100 nanocuries per gram, and it's got the same type origins as do the low-level wastes -- it's protective clothing, glovebox waste, process equipment and so forth. Again, a fairly low generation rate compared to the low-level waste generation of nearly a million cubic feet per year.

This photograph is not in there because we couldn't run the reproduction equipment very well to do that, but this shows the current burial grounds. Remember, this is that part right in the middle between F Area and H Area, and what we're looking at is the engineered low-level trench. These are B-25 boxes, these are light steel boxes that are about four by six, ninety cubic feet or nearly a hundred cubic feet in each of these boxes as they're stacked into this engineered low-level trench.

On these pads right near by are the transuranic waste as it's stored for ultimately hopefully disposal at the WIP. It will have to have some additional processing before it goes through there.

That gives you an idea of what the site actually looks like. I think you might get a close drive by tomorrow. Again, the material that's in there is the job control waste either out of the various process lines or from clean-up activities, the contaminated equipment and shielding that's no longer been valuable, some old reactor and fuel hardware that's in the burial ground, there are spent resins in the burial ground, and these have not been put in there for the last five or six years, as well as some spent targets.

The history of the disposal practices, of course there's shallow land burial, but it originally started in about 1953 and continued to 1985 where the waste was packaged in cardboard boxes or transported loosely in dumpsters, basically dumped in trenches, and those trenches have since been filled in. Recently the ground over those trenches has been compacted.

But in 1985 and to the present we're much more into engineered low-level waste trenches, the waste is in the steel boxes, they're stacked tightly in a close array. It gives us much better utilization of the space in the burial grounds.

And also in 1985 there were some greater confinement disposal demonstrations that started. Boreholes were dug that were lined with concrete. These have mainly been filled now with drums.

There has been a greater confinement disposal trench that has the bulkier waste in it that's also more of an intermediate-level-type activity waste.

This is a gravel-floored trench, but it has concrete sides, and it's much akin to the -- I guess its precedents were a slit trench-type disposal for this waste.

In terms of the total amount of high-level waste which is the one thing we haven't talked about really, and the high-level waste being that waste that results from the processing of fuel and targets, you can see that the Savannah River Site has the lion's share of that waste from the whole Department of Energy/Defense activities with 53.8 percent. Hanford has a large portion too at 37.5 percent, and there are other sites that have some waste.

On our site the waste generation that has come from the processing of the targets and fuel assemblies has in the past historically averaged two to three million gallons per year. This is in a liquid form which is why the rate is given like that.

All totaled there have been about 86 million gallons of fresh waste that have come out of the canyon or separations facilities, and we've been able to take that and concentrate that through evaporation to about a little less than half of that, 35 million gallons, with a current inventory of over 600 million curies.

The characteristics of this waste, there is a certain layer of sludge that forms in the bottom of the tanks where the waste is received from the canyons, and it's primarily iron hydroxides, aluminum hydroxides and manganese dioxides, insoluble.

A large portion of the waste is a soluble salt composition, sodium nitrate, sodium nitrite and sodium hydroxide.

We do separate the waste by heat content as it comes out of the canyon facilities. When it comes out of the canyon facilities the higher heat waste has to be kept and aged for a period of time before it can be processed further. Those high-heat wastes are then wastes that have sludges that might range from 50 to 100 degrees C in terms of heat generation, and other wastes that are lower temperature wastes.

This is a photograph to try to put that in a little perception in your minds. There have been roughly -- there were 51 tanks that were actually built, there are roughly a million gallons per tank. This shows H Area, and in H Area this particular part is showing an elevated section, this is dirt that's been pushed up that surrounds the tanks. They don't show up as well there as I had hoped they would, but you can see here are four tanks that are sitting here on top of this, and there are other tanks in that part of the picture. These are the tanks that have received the waste over the years.

Let's see if this picture is any better. These are tanks in F Area, and it gives you a better picture of the top of the tanks.

This is the canyon or separations facility where the wastes were generated before they came in here to the tanks, and down in here you can see some of the older tanks that are down in a recessed area.

All of the tanks do not have waste in them, but again there's about 35 to 36 million gallons of waste in those 51 tanks and spread about.

The waste is concentrated. After it's received in from the canyons we collect it into a fresh waste receiver tank, and there you see some separation of the sludge and a supernate that develops in top. That supernate then is transferred to an evaporator feed tank, and from that feed tank is cycled through an evaporator where the overheads are no longer measurably radioactive, and they go to the effluent treatment facility where the final scrubbing is done to remove any radioactivity left before the overheads are actually released to the streams on site.

The evaporator bottoms are returned back to a receiver tank where salt cake forms. The specific gravity of those bottoms is such that once they're in the tanks it actually tends to crystalize, and we have a lot of tanks that contain just saltstone.

The supernate layer that's on top can then be recycled back through the evaporator feed tank bank through the evaporators until we really concentrate it absolutely as much as possible.

The waste segregation can be shown in this type of picture. Again, we have four different streams of waste coming from the two canyon facilities. Each canyon produces high-heat waste and low-heat waste, and therefore we have two canyons, two streams each for four streams into the receipt tanks, and then this is a replay of what we said before.

We're able to send the supernate off of that sludge through the evaporators with the overheads going out to the effluent treatment facility, and the bottoms come in to salt receipt tanks, and that's where the bulk of the waste volume is now stored.

This is sort of a summary slide that takes us through the overall flow sheet for the high-level waste, and that I think is the main waste that we want to focus on today.

From sludge tanks the plans are to remove the sludge, run it through a sludge washing process where we go through aluminum dissolution to remove the aluminum from the sludge, and then finally that sludge will be fed into the Defense Waste Processing Facility for dissolution into the glass waste form.

The salt which represents the bulk of the volume of waste will go through an in-tank precipitation process. From the tanks where the salt is stored it has to be redissolved using water, and the in-tank precipitation facility allows for the precipitation of cesium from the salt in the form of a cesium tetraphenyl borate.

There is also strontium and plutonium removed in the in-tank precipitation process, and with the radioactivity being processed in through the Defense Waste Processing Facility to go into glass.

The decontaminated salt solution ends up going to our saltstone facility where it is mixed with cement, slag and flyash and cast into a form where it sets up and solidifies.

I think that pretty much finishes my overview, and that will get us maybe back a little bit closer to your schedule, Dr. Verink.

CHAIRMAN VERINK: Very good, Clyde.

That puts us right on schedule, and I believe the next item is a little nourishment for lunch.

I suggest that we all take care of our individual needs on that and be back here in time for the afternoon session which will start at one-fifteen.

(Whereupon, at 12:05 p.m. the meeting was recessed, to reconvene at 1:15 p.m. in the same place.)

AFTERNOON SESSION

CHAIRMAN VERINK: If anyone is out in the corridor, we'd like to get started.

MR. CHACEY: Just a couple of quick words about the tour for tomorrow.

We'll be meeting the group out in the lobby area at a quarter till seven, 6:45, and the buses will go from that point out to the site where you'll be badged and then go through a whole body count.

You'll go out to S Area and hear about the program activities out there, and then go through a tour of the Defense Waste Processing Facility.

At that point you'll be put back in the vans, you'll go out to TNX which is the demonstration site that we have located at the western part of the facility.

You'll eat lunch out there, you'll go through some of the programs that we have set up out there such as the integrated melter system and get briefings on those.

You'll go back through the whole body count, go back and turn your badges in, and then the plan is to try to have you back at the motel here at five o'clock.

In addition to that I'd like to say that Jeff Allison worked real hard in trying to work with the board as well as with the people from RW, Steve Gomberg and the people here at Savannah River in trying to set up the programs, and I thank them in that endeavor.

Clyde.

MR. TERRELL: Good afternoon. I trust everybody had a good lunch.

What we'll talk about now is sort of an overview of the Defense Waste Processing Facility, or DWPF as I'll slip into calling it from time to time.

Of course, the purpose of the Defense Waste Processing Facility really is to stabilize all of the high level waste that has been produced over the years.

In this slide I'll replay some of the things that we've talked about before lunch, but you do get to go back and get the big schematic of what goes on.

Fuel and targets historically were processed through the canyons for the chemical separations, or chemical separations facilities.

Product from that separation is shipped off site, and from that you have resulting waste. You see here there were 24 original waste tanks that were designated Type I, Type II and Type IV waste tanks, and 27 Type III tanks, also called the new high-integrity tanks. These Type III tanks are double-shell tanks, and have an exhaustive maintenance and monitoring program that's run on them.

Salt solution from the waste tanks is processed through in-tank precipitation. The in-tank precipitation process uses sodium tetraphenyl borate to precipitate out the cesium which is the bulk of the curies in the waste, and then there's sodium titanate added to remove any plutonium and strontium.

The precipitate in ITP is washed thoroughly, and then it's transferred to the Defense Waste Processing Facility where the first treatment that's run on the precipitate is a precipitate hydrolysis.

Sludge that settles to the bottoms of the tanks has to be processed, and is done so through an extended sludge processing activity.

This in-tank sludge processing does a couple of things. It washes the sludge to remove any of the soluble salts that are still there, and then that can be reprocessed, recycled back through and come through ITP, the in-tank precipitation process, and the aluminum that's in the sludge, any aluminum is dissolved and removed with the resultant washed sludge going to the Defense Waste Processing Facility, and it enters actually in the melter feed preparation part of the facility.

The salt solution that was decontaminated if you will -- remember we precipitated the cesium and removed the strontium and plutonium, so we're going to refer to that as decontaminated salt solution -- goes to the saltstone facility where it's grouted and put in these forms. I'll show you that in a little bit more here.

Of course, this reorients you to the site, and you can see the outline -- I don't think this slide came out well in your handout, but we're really talking about F Area being one part of the separations process, and some of the waste tanks are located there. There is an interarea line that connects F Area to H Area, and H Area is where the in-tank precipitation process, the sludge processing and remaining tanks are located, along with another separations facility in H Area.

The burial grounds are located in between. S Area is where the Defense Waste Processing Facility is located, and Z Area right across the street is saltstone.

Again, another map. This particular inset shows some of the interarea lines that do connect from the tanks in the in-tank precipitation process, the tanks that actually feed the highly radioactive components into S Area to the Defense Waste Processing Facility, and a line that goes from Tank 50 which transfers the decontaminated salt solution over to the saltstone facility.

Saltstone is not an extremely complicated facility. It started up and processed the first decontaminated salt solution in June of 1990.

Now, even the decontaminated salt solution has some amount of radioactivity still associated with it, but the maximum exposure rates that we're planning to see against the side say of one of these vaults would be in the neighborhood of 5 MR per hour, so it's very low level radioactivity.

But the idea is that we're going to blend flyash, slag and cement -- and really it's about 25 percent flyash, 25 percent slag, maybe 3 percent cement, to a 47 percent salt solution ultimately being mixed and transferred into disposal form.

Maybe a little better picture of the flow is shown in this diagram where the salt solution coming from Tank 50 -- and that's one of the tanks associated with ITP, the in-tank precipitation process. The salt solution is received in a hold tank, and then the cement, slag and flyash are received in bulk and stored and blended in a premix blender for transfer into a bin.

That bin then feeds right into a mixer where we also get a retardant and a process, a clean process water to further adjust the solution, and the salt solution is added. They are mixed into a grout, it's like a buttermilk, it would remind you of the consistency of buttermilk as it's mixed and held in a hold tank and pumped into the disposal vaults.

There is a flush water system that allows us to clean out those lines so that we don't have any grout set up, and we chase those through with a pig, and that pretty much cleans it out.

The vaults or forms as I've called them for the saltstone are about 600 feet long, 100 feet wide, and about 25 feet high. It has a moveable roof, and the roof is kept over the section of the vault that's being filled. There are six sections nominally to a vault.

We have done a couple of different vault designs or form designs. I call them forms simply because they're concrete walls that we pump the grout into and let it set up.

This is the particular form or vault that's on service now, and you can see it has a two-section roof that's over it. This is the raw materials receipt up here where we bring in the raw materials and transfer those down, and the heart of the operations are in here where everything is mixed and blended, and then the material is pumped over into the vault.

This is actually being run today. There's a fair amount of material in Tank 50 that was over in the ITP process from an experimental run, and then also we end up with some recycled from the effluent treatment facility in there. But it's pumped into those forms, and we have the saltstone.

The other part of stabilizing the high-level waste is doing something with the bulk of the radioactivity, and that happens in the Defense Waste Processing Facility. This is an aerial of the facility. Tomorrow when you come out we'll get to start here in the operations building which houses most of our office staff, and we have a little model we can show you there.

From that point we'll go into the vitrification building, and in here we'll see the control room, and in the vitrification building are all the rest of the parts where the radioactivity is really processed in the glass.

We have service buildings, and we have places for receipt of our bulk frit, frit being small glass beads, and this is the glass component that we're going to dissolve the radioactivity in.

We have a cooling tower, a sanitary sewage facility, we have a sand filter with a fan house and exhaust stack for Zone 1, the highly radioactive part of the facility ventilation, and then in this part of the picture you can see a glass waste storage building. This facility is designed to hold about five years worth of canister production. The glass once it's processed is poured into canisters, and those canisters can be stored temporarily in the glass waste storage building.

Back over here in this corner you can see part of the H Area facilities, but the ITP process is off the picture over in this part and you really don't see it. We saw that in an earlier photo this morning.

This diagram pretty much depicts the entire DWPF process. Back from the tank farm we had the decontaminated saltstone. We're going to bring the precipitate in, and the precipitate again is in the form now of the cesium tetraphenyl borate as the predominant radioactivity that's coming in there.

The first thing we really want to do is do a hydrolysis of it to separate out the organic portion. The sludge is then added to the aqueous, and the radioactivity resulting from precipitate hydrolysis with that feed preparation then running up until the melter where we actually heat it up to about 1,100 degrees Centigrade. The resident time of the material in the melter is in the neighborhood of sixty hours, and it will be poured into canisters.

The canisters then need to be decontaminated because the atmosphere in the melt cell itself has got some radioactivity and an oxide layer forms on the surface of the canisters. The canisters are decontaminated by blasting them with the same frit that's actually used in making the glass, and that spent frit from the decon activity is routed back through feed preparation, mixed with fresh frit and goes back into the melting process.

Once the canisters have been decontaminated, there is a weld and test activity that they go through finally to the glass waste storage building for temporary storage until they can be sent to a federal repository.

To go through the steps that happen, remember the precipitate comes in, the cesium tetraphenyl borate, and it basically comes in through a precipitate reactor. The wash precipitate comes in, and we use formic acid with a copper catalyst to basically drive the hydrolysis. Hydroxylamine nitrate is proposed to be added to break down a nitrite that's been added back in the tank farm to preserve the tanks. One of the corrosion inhibitors for the tanks in the tank farm is sodium nitrite.

This is a proposed process, and we're actually working now to see if we can't radiolytically decompose that nitrite and maybe eliminate the hydroxylamine nitrate from this part of the process.

But at any rate, from the precipitate reactor we're going to reflux this material is the bottom line, we're going to boil it up and run it through a condenser/decanter and separate the organic phase from the aqueous phase. Ultimately we'll take the aqueous phase and the radioactivity and that will go on to the feed preparation.

The organics that come out, primarily benzene --

it's about 80 percent benzene after we do this digestion -- ends up in an organic waste storage tank, and we have capacity to hold about three years of benzene and other organics from running the process.

The actual melter feed preparation. Okay. Now is when we're going to bring in the sludge. This is the washed sludge, not the raw sludge that settled in the bottom of the tanks, but it's been washed to remove the excess salts, the aluminum has been dissolved, it's been washed. The sludge is going to come in and be blended with the aqueous part from the precipitate hydrolysis, the PHA.

Formic acid again is added here, this time though to aid in reducing and collecting the mercury. The mercury goes off to a mercury purification.

The mercury was introduced in the process way back in the canyon, in the separation facility, and this is where we'll recover that mercury so there won't be mercury in the remainder of the stream from here on.

Frit is added then. Once we have received all of the waste in, frit is added and it's going to go through a process of mixing that and evaporating it. We have to concentrate it to the right mix for putting it into the melter feed tank. This is also about the last place to really do any fine tuning on the chemistry, and this really controls the quality of the product that we're going to get out.

The melter feed tank keeps things agitated and stirred up, ultimately going to the melter, and what we do end up then boiling off from the slurry mix evaporator we collect in the slurry mix evaporator condensate along with the mercury wash water, and that water than is recycled back through the tank farms, it can go back through the evaporation process and start coming through again through the in-tank precipitation, so there is a net reduction all along in the volume of waste.

The melting process I think we've pretty much already described. The melter feed actually comes into the melter proper -- there's an off-gas system associated with the melter -- here again I said we'll say about sixty hours in the melter at roughly 1,100 degrees Centigrade, it's a pour-spout arrangement -- I've got another picture of the melter -- we'll fill the canister, and then put a closure in it. Once we've done the inner canister closure we'll let it cool, leak-test it and send it on for decontamination.

I hope that tomorrow you'll get a chance to see the melter up close and personal. It is an impressive cell. But the main part in that cell is the melter. Its dimensions you can see interior -- this is a nominal exterior I guess, it's ten feet tall, eight feet interior, and then across this way is eight feet, and about six feet from interior -- eight feet external, six feet internal for the melter.

It's lined with refractory brick, it has electrodes that pass current through the molten glass pool, it's a Joule heated melter. We have the capability to monitor it with closed-circuit television, we can actually see what's happening inside the melter and observe the cold cap that will be on top of the melt pool.

Feed is done through two different feed tubes, eight-tenths to a gallon per minute, so it's not a real rapid feed rate coming in, but more than adequate.

You can see here the off-gas system is accommodated, and the pour is done by differential pressure to pull the molten glass up and out the downspout into the canister. There is a bellows arrangement up there that you don't see, but that accommodates for some expansion of the canister neck.

Actually the melt cell has filled up a little bit, and you won't see the picture in your packet because it doesn't reproduce well, but these are the holders for the canisters, and this is the melter proper with the pour spout extending out at you. When you see it for real you can get a little different perspective on it, you can see how the pour spout sticks out, and we've got some canisters in there, and a lot more of the support equipment is in that cell today.

Once the canisters have been poured, they go through the decontamination process, and I described that. That's where frit is used to blast the oxide layer off the outside of the canister that forms once the glass is poured into the canister.

Once it's decontaminated it goes to a station where we do the smear test to prove we've decontaminated and the exterior will meet any Department of Transportation requirements in terms of transferrable radioactivity on the surface of those canisters.

And then we're going to go in through and press the canister closure plug and really seal this thing up using an upset resistance weld. Finally there will be an additional inspection, another smear test, and we can transfer the canister to the glass waste storage facility.

The canister itself is almost ten feet tall, a couple feet in diameter. You can see that the net weight is nearly two tons, 3,700 pounds total, but only 56 pounds of that are actually radionuclides. We'll be in the neighborhood of 5,500 R per hour to 6,000 R per hour at the surface of that canister, but the exterior contamination is less than 10 to the minus 4th microcuries per square centimeter, or as I think the Department of Transportation does it 220 BPM Beta-Gamma per square centimeter, or 22 DPM

Alpha, but we'll verify that all those are met.

It's a very interesting thing to get the opportunity to see I think.

This is a transporter, a picture of the transporter that actually moves the canister into the glass waste storage building. In this section here is a four-ton hoist, and you'll see tomorrow how canisters are moved around in the facility, they come out underneath the shield plug, and then the transporter can position itself over the shield plug, remove the canister up into the shielded housing, and the operator can sit here and be exposed to less than half a millirem per hour and move the canister from the actual Defense Waste Processing Facility over into the glass waste storage building.

Now, I've really focused on just the one facility, the Defense Waste Processing Facility, and talked about it as a single entity, but the final slide I think in your package is intended to show that the facility is really a system, and this is also the summary slide.

The system encompasses everything from F Area with the storage tanks that are there, and then in H Area we have all these different things, some of which we didn't really even talk about. We have recycled waste, and I've talked about the recycled waste that's going to come from the DWPF, but we're having to build a new waste transfer facility to accommodate that recycled waste.

Also part of the sludge processing activities that come through the new waste transfer facility, as to the salt materials that are being transferred from the tanks in F Area.

The in-tank precipitation process is still in H Area, and of course the precipitate slurry from that is going to end up coming through now another auxiliary pump pit still in H, but then we have a low point pump pit in S Area, and the material comes on in. This is our wash precipitate coming into the Defense Waste Processing Facility.

Of course we have saltstone and the vaults associated with it in Z Area, and the S Area where the DWPF and glass waste storage building are located.

I think we're close to being on schedule again, and Bill Pearson now will do the next talk.

MR. PEARSON: I'm Bill Pearson with the Department of Energy at the Defense Waste Processing Facility, and I'm going to focus on the waste form producer program.

Just to kind of focus where the waste form producer program comes into play I'm going to put this slide on, and Clyde has talked about a lot of the other operations on site and NDWPF, but I want to talk about vitrification right now, and more closely focused than that the actual waste form production portion of the vitrification facility where we take the feeds and bring them together at the melter feed tank, measure at the melter feed tank before we feed into the melter.

As part of the program we respond to the specifications that RW has, that's the waste acceptance specifications, and also their quality assurance program specifications, but later on I'll talk about the quality assurance program.

Right now I want to talk about the waste acceptance specifications and documents under that. Dr. Plodinec will be talking about compliance plan and WQR. Sharon Marra will be talking about the product control program.

RW's role of course in the program is to generate the waste acceptance specification, to impose quality assurance requirements on the waste form production, and to participate in reviews of the documents that are generated and, of course, to interface with the NRC.

When I talk about waste form production I'm talking about production of the glass, the waste into glass, and then the canister that it's poured into, as I said the package.

We look at the role of the waste form producer, then, that's the people making the glass. We have several different things that we need to do to respond to the specifications.

First of all I want to mention that right now there are three waste form producers who are planning to make glass -- West Valley Demonstration Project, Hanford Vitrification Project, and then the Defense Waste Processing Facility.

The waste form producers of course need to prepare a plan that responds to the specifications with their approach for meeting those specifications, and that's called the Waste Compliance Plan.

We also need to prepare documentation from tests, research and development activities which shows that the producer can perform the activities described in the plan. That comes as Waste Qualification Report and Product Control Program, both of which will be discussed a little later.

The waste form producers also produce a Quality Assurance Program Description which I'll talk about later on, they develop the Product Control Program, they conduct research and development, and process qualification testing we term cold runs. Particularly we're going to talk about the vitrification portion of the cold run testing as part of the production and process, and then the waste form producers actually when they get into operation produce the waste form and generate production records to show that the waste form they've produced will meet the waste acceptance preliminary specifications.

A very important part of the waste form program is the technical review group, referred to as the TRG. The technical review group is the headquarters oversight group, and the participants in that group are independent of the waste form production going on at the vitrification facilities.

The group is composed of consultants, headquarters project support office personnel, both people from the Office of Civilian Radioactive Waste Management Headquarters group and the Yucca Mountain Project Office.

The TRGs review the compliance plan to see that the activities are described sufficiently to satisfy the waste acceptance preliminary specifications. The group understands and accepts the specifications criteria as a given.

When the group reviews the waste qualification report to see if the requirements of the specifications were met, they accept the compliance plan at that time as a given.

Dr. Plodinec will now go into a little more detail on the compliance plan.

DR. PLODINEC: By nature I'm something of a klutz, and I'm going to do my best to prove it to you.

I think psychologists tell us that each of us as individuals have both all the positive and all the negative attributes combined together, and our success is how well we accentuate the positive.

This was brought home to me when I first saw the agenda and I saw that I was supposed to spend a considerable amount of time with you after lunch, which is something that has fallen to me quite a bit lately.

So the optimist in me said "Ah, they've finally recognized what an outstanding and enthusiastic speaker that I am, and they've got me here to keep you awake."

The pessimist in me said "No, they figured the subject was so dull that they wanted the dullest speaker they could find so he wouldn't wake anybody up from their post-prandial nap." In spite of that, I am combining both attributes and going to give this talk.

I'm saying that only partially in jest because our product qualification programs do combine a wide variation of disciplines, diversity of viewpoints as I think will be apparent, and perhaps that's the main point that I'll be trying to make to you besides of course the overt one that we've made a lot of progress.

I won't say too much about the product. You've heard some about that already and how it's made.

I will point out that the maximum decay heat as opposed to some of the slides you saw this morning which were more geared towards averages, the maximum decay heat for any DWPF canister should be on the order of about 730 watts. The average density will be about 2.7 grams per cc. That's how we get the 3,700 pounds, and as Clyde has said, we'll be pouring by a continuous method of differential pressure.

The board has seen some of these slides before, so I'll go over them very quickly, these early ones as far as the background is concerned.

We're a very old program compared to the present reincarnation of the repository program, in that we've been going since about 1973. We had groundbreaking in '83 which was preceded by the NEPA process for the DWPF when we selected the waste form for the reasons that you see here.

One way to look at the specifications that we have to meet is a way of us proving to the repository program that the technology that was developed in many cases long before there was a repository program, or OCRWM, or before there was -- certainly before there were specifications -- will in fact produce a product that they can accept for emplacement and subsequent disposal.

We are working to establish compliance with those specifications through a combination of specifications on our own components, for example the canister that we buy, the glass frit that we buy, and control on the product. For example, how we mix the different waste streams together, and we'll talk a bit about just about all of those in the next few minutes.

This is a bird's eye view of the waste acceptance process. Basically RW gives us specifications which we have to meet and document that we have met in three forms of documentation, a compliance plan, a qualification report and a production record. The compliance plan, how you're going to comply; qualification report, can you comply with the specifications, sort of a generic statement; and the production records, have you in fact complied per canister as S00191, et cetera, et cetera.

All right. What are those specifications? Well, they cover three technical areas as well as quality assurance. The quality assurance spec basically points to the repository quality assurance requirements document and says "Go do that."

The specifications themselves deal with three technical areas -- the glass as a part of the waste form, the canister and what I will call the finished product, or what's called in the specification the canistered waste form. This includes everything that's within the sealed envelope of the canister, and you can see the laundry list, and I'll march through these in some more detail in a moment.

Where we stand right now, the WAPS as was said on the earlier slide was revised in June of '91. The major difference was the so-called product consistency test was included and the language was changed somewhat from the previous specification, but I think throughout anyone who's read the specifications, the old version and the new version, will see much improved clarity in large part because of having to go through the technical review group process and being beaten up about the poor language or poor choice of words that were used in the past.

We have written and rewritten and rewritten waste form compliance plan which has been revised as we've made advances in the facility or in how we're going to operate it, but most recently of course to match the revision in the WAPS. That's currently undergoing review by the technical review group that Bill referred to.

The qualification report, we had previously prepared 16 out of 24 sections of the qualification report which had already gone through the technical review group. With the new WAPS we've taken those back and we're revising them. To give you a better idea of where we stand actually we're about 70 percent done overall, even though we don't have any of the new sections actually issued.

A very important component of our program is the start-up test program, a very disciplined approach that's been borrowed from the nuclear power plant business. This disciplined start-up test program is now in place, we've done our water runs.

The primary purpose of course is as you see here, qualified technology that's for us very old certainly in relationship to the specifications, demonstrate the ability to control the product during production in the facility, and then finally I think I have to observe as you'll see a little bit later that this overall program in terms of its scope is being driven to a very large extent by two groups of specifications.

First the one that deals with product consistency, or glass durability if you will, and secondly those that deal with foreign materials.

The compliance plan is perhaps the most important document for us in the entire program. In that it is our plan -- of course we give it to the repository and take their best shots -- but it really is a very important and useful management plan for ourselves to how we're going to go about wrestling this bear to the ground.

It defines the methodology that we use to determine what's important, what things do we have to control. Clyde showed you a rather big melter. Well, do we have to control every single part of that for the repository program? What is important?

Well, the compliance plan acts as the vehicle that lets us do that, lets us make those decisions.

It also provides descriptions of the programs and the activities we're going to be carrying out both from the qualification stage and during production, and then how we'll report on those activities, and how it does it for each specification.

Start-up test program I've already talked about.

From the standpoint of QA it is the key technical document. It details what we're trying to achieve, it describes the actions that are going to be taken to achieve those objectives, and as I said it gives us a vehicle to identify what we need to control.

Now, the next slide is not an eye chart, believe it or not. This comes right out of the compliance plan. I struggled with trying to figure out how I could describe to you what the compliance plan looked like, and I guess the best way I can describe it is just simply that it has for each specification a logic diagram such as this, and the text basically describes this logic diagram in words and fleshes out the skeleton that you see here.

Important points to know on these are in this logic diagram we identify for example what's going into the qualification report, things that are in this octagonal shape, what's going to be in the production records, things in the oval, and so forth and so on.

As I say, it is the most important for us in terms of keeping our arms around our own program.

The qualification report of course is just the -- not just -- the result of carrying out the compliance plan. We have broken it down into volumes to allow ourselves to resource level some, and also to facilitate the review process, as you can see in the next bullet, over 3,000 pages when all is said and done. That would be a rather hefty thing to have on anybody's desk or chest late at night, and I didn't want that on my conscience.

So we've broken it up unto individual pieces so that specialists in a given area can look at things that they know about and can cogently review and not get lost in detail in some other area.

Each volume basically contains the specification that it's trying to respond to, summarizes the strategy for compliance from the compliance plan, describes in as much detail as is necessary the item or the process or what have you that's controlled by the specification, then perhaps the most important part of it then details the process control that will be in place for that particular item.

Then the testing, the qualification testing if you will, which demonstrates the effectiveness of the controls that we applied.

Then finally this describes the contents of the production records, of the shipping and storage records as it may be.

Now, for the rest of this talk what I'm going to do is to march through each of the specifications grouped according to the volume of the WQR, give you some idea of what the specification is that we're trying to deal with here, and where we stand in terms of the progress.

Please, if you have any questions I'd be happy to entertain them.

The first volume will deal with the chemical composition projections. What the specification requires is that we give the chemical composition of our products over the lifetime of the facility as best we can, not only the chemical composition but also the phase makeup expected for our entire output.

As Clyde indicated to you earlier, we don't have just one type of glass or one type of waste if you will, we have as many as forty or fifty, one for each tank.

We have to put that together in some form that the repository can use to facilitate their testing so that they know what they're going to get.

What we have done is to define reference waste types and the glass composition for each waste type. These waste types correspond to what will be going through the facility in large batches.

We have also procured several pounds of each type of glass prepared under a very controlled program from Corning Glass, and at have at the same time in our semi-work testing determined the expected cooling curve for our canisters.

What we've then done is taken the glasses and exposed them, these projected glasses to the expected cooling curve so we could identify in detail what the phase makeup of the glass might be.

We're almost completed with this characterization of the glass. It's still a little bit open. We just have the quantitative X-ray diffraction to do and then we'll be able to close that.

The next slide shows those compositions that will be tested later. I will say just to help you through the chart a little bit, the blend represents an average of all the waste that's out in the tank farm. Batch 1, 2, 3 and 4 correspond to the major sludge batches, each one will take two to three years to process, so the first four batches correspond to the first ten to twelve years of production in the DWPF.

HM and Purex correspond to the two major waste types that we get from our canyons. HM is if you will a best case, high in aluminum, we've backed off on the fluxes going to the facility, taking the lowest flux rate or pHA rate in.

The Purex is actually a worst case that once we get into our product control program we probably could not make in the facility without violating our own rules, but in fact it's not denied to us by nature so we include it as a sort of credible worst case.

I have included in your package some representative cooling curves for the canisters. This is a center line of the canisters shown at the time after completion of pouring. You can see that at the center line the initial temperatures may be as high as almost 900 degrees C, and the transition temperature is on the order of about 440 C, so you can see it's somewhere around, depending on what location, 16 to 20 hours will be down below the softening point and the glass will be solid after that.

If we look at the effects of center line cooling, in other words if we look at the glass that might be for example the most crystallized and compare the releases on the product consistency test which I'll describe in a moment to those of the quenched glass.

You see that for most of the glasses with the exception of our worst-case glass there's really no effect, there's very little crystallinity and what little bit there is does not affect the durability of the product.

Volume II is a production specification dealing with reporting of chemical composition. It requires us to report the content of any element that's present at greater than half a weight percent with the exception of oxygen, and do that on what's called a waste-type basis, and then report the precision and accuracy of those values in the WQR.

For reasons that I won't go into at this point, but certainly are open for question, we've decided to do this on the basis of our slurry samples. We'll be taking a lot more slurry samples than glass samples, quite simply, and we can get a much better picture of what the glass is going to look like through analysis of those.

This has been incorporated in our product control program, so we'll talk about that more a little bit later.

We'll report on the basis of what we call a macro-batch, which is any time either the precipitate or the sludge changes in composition we'll say that's a new macro-batch. It will correspond to about four months worth of production, so that will be a waste type so we'll if you will take the average of all the slurry samples over that amount of material.

We have developed our sampling equipment, we're developing our analytical procedures. We have already developed the methods and shown that they work in the laboratory.

We have found a very important point is use of standards, particularly standard glasses can be extremely important, and will be extremely important to assuring that we receive good analytical data back.

We'll also use glass samples to confirm our analytical results. We have developed a glass sampler. Where we stand right now is we're getting into the facility, we're starting to use our analytical procedures in the facility, and we're working to quantify what I'll call the as-builts, as-built uncertainties as part of our start-up test program.

To give you some idea, though, as to how the methods are looking, we have been participating in material characterization center round-robins along with several other sites, and I really do want to brag on our folks because they have done an outstanding job I think as is shown here.

You see here the reference value which is the average obtained by Corning Glass Works for this reference material that was used for this round-robin.

The DWPF method is the method that they in fact will use out in the laboratory in the DWPF. You can see the excellent agreement between what we got with our methods and the reference value, and equally important the percent relative standard deviation, high precision analysis.

Turning to Volume III, that deals with the radionuclide inventory projections. This of course I think is quite important for the repository in that they have to know how much to charge us for the radionuclides we're going to give them, and also this is important in doing their performance assessment calculation, knowing what the source term is.

The specification requires that we estimate the total that we're going to shift to them, that we estimate the inventory for each waste type and the potential errors in the qualification report.

They ask that we index the values, both the 2025 and the 3125 to give a view as of around the time of shipment and one after the containment period.

We have developed the projected glass types estimated in canister production and have developed canister-by-canister estimates as well as bounding cases for the total inventory.

One of the problems that we have is that we're still an open, we're still a producing site. We're making more waste, we don't know if or when we'll stop, so it's sort of an open-ended projection.

If you look at canister production, these are the latest numbers for canister production, you see that out to the year 2025 we estimate some over 7,000 canisters will be produced.

If you looked at the existing waste, it would be somewhere about 5,400 canisters that we would produce over the next fifteen years to handle all the waste that we have right now, as well as what would produced in the meantime.

That's an important input of course to determining the content of each canister. If we look at the total amount of radionuclides what we've done is to say well, let's take one case where we just look at the current inventory, no additional waste generation, what might that be in terms of the amount of radioactivity that we would send to the repository, and that's this lower bound, and the upper bound reflects continued production out through 2025, so you can see that somewhere between 310 and 620 megacuries will be the amount that we would be sending to the repository through the year 2025.

Also in Volume III will be heat generation and dose rate projections. The dose rates are both gamma and neutron, we have to provide a maximum and a range. These are basically calculated from the radionuclide inventory projections, and again we've also provided bounding values.

I show the heat generation rate here initially about 730 watts for our worst case class, and in the case also of after 1,000 years we're down about one watt.

Subcriticality is also called for, we have to make sure that the waste doesn't go critical either at our own site or when the repository gets it. The way that we've wrestled with this specification is basically to perform very conservative bounding calculations where we assumed about four times as much plutonium as we're actually going to have, or fission material I should say, have then assumed an infinite array and have taken no credit for the boron that's in the glass.

Even doing all of that, we still end up with a K-effective of slightly less than .27.

If you take more realistic calculations for the first four batches we end up with a K-effective of about 0.0X, so virtually zero for the first few batches, and everything else from then on.

Volume IV deals with -- just as Volume II dealt with chemical composition during production, Volume IV deals with the radionuclide inventory during production. For this specification we have to report all radionuclides which compose greater than .05 percent of the curie inventory at any time up to 1,100 years -- I've got to read this -- with a half-life greater than ten years.

This is mostly in response to 10 CFR 60's requirements, and particularly the one part in 10 to the fifth requirement.

We developed a strategy which is based on reporting most of the elements indirectly based on analyses of samples that come from the tank farm. The way this would work would be that we would get a sample from the tank farm, we would measure the ratio let's say of nickel 63 to total nickel, when we went through the facility and got a nickel number we would multiply by the ratio and that would be our nickel 63 number that we would report.

We would use direct analyses for those things that we can analyze in the facility -- cesium 137, strontium 90, some of the Alphas, and other Gammas if they are high enough.

It turns out that the real key to meeting this specification is going to be in inductively coupled plasma mass spectrometry which allows us to analyze very precisely elements at extremely low levels so that our ability to report actual numbers as opposed to some sort of a computer-generated number has been extremely enhanced.

Right now we're actually characterizing the initial DWPF feeds, and that will all be documented in the qualification report.

Volumes V and VI deal with the product consistency specifications, known informally, though not to RW, as the glass durability specifications. What it requires is that we control our process so if the glass is better than the glass which was the basis of our successful navigation of the NEPA process, and better defined to be lower releases of lithium, sodium and boron on this product.

Not only do we have to be just a smidgeon better, but we have to be -- our mean value must be greater than two standard deviations below the mean of that glass.

I'm not going to talk too much about this spec right now since Sharon and I will be spending a bit more time on that later, but just as a quick overview on the progress it appears the control of the feed composition is the key to compliance based on all the testing that we've done.

We will do again occasional glass sampling to confirm control, but our primary method of control is going to be on the feed composition, and in fact our reporting will be based on that as well.

Right now we're working on characterizing the glass standard. We bought about a thousand pounds or so of this glass standard which we're sharing with all of the DOE sites who have need of it, so we can all be testing against the same standard material.

We have incorporated our product control algorithms if you will in what we call, in a software program which we call the Product Composition Control System. This software has been developed and has been tested, and it's recently been updated to match some of the deficiencies found in testing.

We are ready to deploy it, and we will test that in the facility during the start-up test program. Right now, though, we're very confident in its ability to do its job because we've tested it on actual wastes in our hot cells as well as in pilot plant testing.

I've talked a bit about this product consistency test. It is compatible with production, the kinds of samples we get during production. The test conditions you see here, it's a grain-glass test where we take the glass, crush it up to 100 or 200-mesh size, we use a standard glass -- in this case we used the EA glass -- and stainless steel vessels.

What we found from round-robin and radioactive sample exchanges is that the test gives very good precision, it's very sensitive to not only composition but to the if you will fluctuations in composition, in other words the homogeneity of the product. It's a -- if I can put it this way, a glass-dominated test, so it's a good indicator of how well we have done our job in making good glass.

We are putting it through the ASTM. We expect to get acceptance of the full committee shortly, and then we'll send it to the full membership.

Interestingly enough, the EPA is also interested in the PCT for use as a replacement for their PCLP for vitrified mixed waste, and we have had discussions with them on that.

Volume VII deals with phase stability. What we have to provide are the transition temperatures for each waste type, and time-temperature transformation data for each waste site.

Now, what that is is you take a sample of glass, you heat it to a given temperature for a given period of time, cool it back down, and determine what phases were formed.

This is to allow the repository some idea of what might happen under various conditions if the glass was heated to 700 degrees in their facility for some unknown reason.

On our side we also have to determine the effects of these heat treatments on the PCT results. In other words, what does a certain heat treatment do to the glass.

In our storage facility we have to make sure that we keep the temperature of the glass below the transition temperature minus 100 degrees, so if the transition temperature is about 440 degrees C we have to keep the glass cooler than about 340 C.

Sharon in fact has measured the, or had the transition temperatures of all the projected glasses measured, and she's now working on getting the PCT work done.

We have developed models of our glass waste storage building and applied them to canisters of different heat loadings and what have you, and the result keeps coming back that the temperature of the glass in the glass waste storage building is going to be considerably less than the glass transition temperatures.

Volume VIII is a rather hefty volume, or will be a rather hefty volume because it deals with almost everything that's involved with the canister.

First, the material has to be stainless steel. We have specifications in place for all of the canister components. Most of the canister is 304L, the welding material is a restricted range of 308-type material, some of the specialty pieces are made of Nitronic-60.

We've come to these specifications based on extensive pilot plant and facility experience. We have developed detailed plans for the vendor inspections as well as the receipt inspections on site.

Also in Volume VIII is the section that will deal with the canister fabrication closure specification, which says that the canister must be water-tight after it's sealed, by which we mean 1 times 10 to the minus 4 ccs of helium atmosphere 2d.

As far as our product is concerned, we have developed the specifications again in our canister procurement document for both fabrication and testing by the vendor.

We're using upset resistance welding as the way that we'll seal our canister, and I'll have a slide on that in a moment. It looks to be a very reliable and extremely successful type of weld for our application. It has an extremely wide operating window.

During the start-up test program we'll be doing parametric testing where we vary the parameters that are of importance to this type of weld so that we can define the operating window that we have to stay within, and also we'll go through qualification of both our personnel and our procedures.

The way this process works is that, as Clyde said, we have a temporary seal in place after we come out of the melt cell.

When we go into the weld cell we'll push this down with a hydraulic ram. This gives us a clean surface at the top of the can to weld. We then place a chamfered weld plug in the hole and press down while simultaneously putting about 240,000 amps, 75,000 pounds of force pushing that down to get, to really just soften the material, to get essentially a solid-state weld. In a period of about a second and a half the weld is made, a very impressive thing, and you'll probably see some pictures or videotape of it tomorrow.

This sealed canister then has this weld plug in place as you see here. The actual length of the weld is on the order of about four-tenths of an inch as compared with the nominal thickness of the canister wall of about three-eighths of an inch.

Volume VIII also deals with the specificational and canister identification and labeling. Basically you've got to have a label and it's got to stay there, and you have to be able to see it.

The canister will have two labels, one on the side and one on the top shoulder. The letters are roughly two inches high and are made if you will with a stencil form, but made by bead welding on the side of the canister, so the material is actually 308 welding rod.

As I said, Volume VIII is hefty. It also contains the information on canister impact testing. The repository wanted a specification on the canister as far as its robustness, its ability to be handled in our facility and not have to be handled with kid gloves.

We have dropped canisters that were prepared at our pilot plant under prototypic conditions, both reference-poor conditions and incredible upset-type conditions, dropped them from the seven-meter height both end-on and on their shoulder from above.

The ones that were dropped end-on were extremely dulled, in most cases they just dropped and stayed standing up with almost no deformation.

Those that were dropped on their neck had some push-in if you will of the canister nozzle, but no breaching, and the deformation appeared to correspond to only about 25 percent of the failure strength of the material.

During production we also have to report the weight of the form, it has to be less than 3,500 kilograms, the length has to be less than three meters with the tolerances you see there, and has to basically fit within the envelope of the cask.

In terms of the weight specification we can't fill a canister full enough to violate that one, which is nice.

We have performed measurements on prototypic canisters before and after filling, and what we find is that the filling operation actually makes the canister a bit rounder than it was to start with, but has virtually no difference in the dimensions before versus after.

We'll report based on measurements that are made in a shipping facility. Once we know when we're going to ship, you know, at the appropriate time we'll begin design of that facility.

We can't say too much now about how we would actually do that during production, except to show that there are ways that we could do it.

Finally, in Volume VIII are details on the canister handling features. This is both the nozzle and neck region of the canister, and the grapple that we'll use to pick up and set down the canister.

The specification requires that we describe these in detail for the repository program and give them all the information they can use or that they want on these fixtures. In particular they may want to use our grapple in their repository.

We have designed a grapple, we've got them on site, we've tested them, it's a very robust design, it can handle -- as an example it can handle canisters which are an inch out of concentricity or alignment. It's a very good design, we're quite pleased with it.

Volume IX deals with the foreign materials specification. These specifications really are reflections out of 10 CFR 60, Part 135, the "thou shalt nots" that are in the 10 CFR 60, temperature waste form must not contain free liquids, gases, explosives, pyrophorics and so forth and so on.

One of the first things that we did was to have an independent review of the entire containerization process performed where we had independent people from the design group look at the path of the canister from the vendor to storage on site, moving into the facility and then out of the facility, and identify potential points of ingress of foreign materials, and are taking the appropriate actions that came out of that containerization review.

Again, this was all part of the idea that the DWPF is a very old facility even though it's not running yet, the technology and the movement path if you will of the canisters was laid out long before there were ever specifications, so this was an important activity to determine were there some points that inadvertently were there where things could drip in, or condensation could form or what have you.

Probably the most important part of meeting this specification for us is what we call the inner canister closure or temporary seal. After the canister is filled we put this temporary seal in place, it's a shrink-fit seal while the canister neck is still hot which closes around this cold plug.

This means that when we take the canister out of the melt cell and send it to the decontamination cell and blast it with the slurry of frit that no water gets into the canister.

We have looked at prototypic canisters that have been filled to see what the atmosphere inside the canister might look like. In fact, most of the canisters were under a slight vacuum.

We couldn't find any volatile material really. Based on the detection limits there were about 41 milligrams per canister upper bound of material.

You see the dew points and the relative humidities that were measured in the canister here. Going through these calculations and similar ones it would not be possible even in the depths of a South Carolina winter for us to condense water inside the canister.

Interestingly enough, here was some CO2 depletion in the atmosphere of the canisters that we're still trying to reason out why this is so.

We'll be doing further testing during the start-up test program, and in fact I'll talk about that more in just a second.

As an add-on to this volume we have the specification that deals with chemical compatibility which says that the contents of the canister shall not lead to internal corrosion of the canister.

After all, if the repository is doing everything they can to prevent the outside from getting inside, they want us to do everything we can to prevent the inside from going out.

Not only is there glass in the canister, but of course there will be because we're pouring the glass at a high temperature some volatile material that condenses on the inside. These are primarily salts, primarily halide salts.

The glass itself won't corrode the canister; however, if those halides, primarily halides are inside the canister were it to get wet they would provide a good environment for stress corrosion cracking and things like that.

That means that in order to avoid corrosion this specification boils down to just another special case if you will of the keep out free liquid specification, in this case keep out water.

We'll be doing a lot more testing of this during the start-up test program.

Volume X deals with the fill level specifications. I won't say much about this except to say what the specification is, that the level of the glass in the canister has to be at least that to correspond to 80 percent fill.

We're filling the canister up to at least 85 percent, and I don't see any problem with meeting that.

Volume XI deals with surface cleanliness. As

Clyde mentioned, the canister waste form has to meet Rogiano's tariff for shipment.

We're using an air injected frit blasting process to clean off the outside of the canister. The real key part of the technology, though, is the smearing because that's how you determine whether or not you've passed.

We have developed techniques for that in the facility that we'll be using and, if you will, testing once we go hot. The real key smears, though, will be those again that's in that shipping facility that's yet to be designed and yet to be built.

What we'll do in the qualification report for the time being is merely demonstrate the existence of appropriate technology. Talk a little bit about what we'll be deploying within the facilities for our own control, and then there will be a promissory note as to what we'll do for the shipping facility later on.

Volume XII, the last volume of the WQR deals with heat generation and dose rate. During production we're not allowed to ship any canister that's hotter than 1,500 watts to the repository, and the dose rates have to be less than you see here.

What we'll do is we'll measure the dose rate in the shipping facility, but will calculate the heat generation rate from the rate of the in-site inventory. At least that's our plan now.

It turns out that the heat generation rate if you measure cesium and of course barium, strontium and natrium and plutonium 238, that accounts for greater than 95 percent, almost 99 percent except out about a hundred years of the heat that's generated in the canister, but we'll report -- we'll do the calculation and put that in the production record.

As I said, the dose rates will be measured in the shipping facility. We'll just show that there is technology and again point to what we'll be using in the DWPF itself as examples of how we might do it.

A very important part of our program as I alluded to earlier is the start-up test program, and it can be thought of as containing three different types of tests, those that deal with operation of the facility, things like shielding, emergency power, running the cranes, the HVAC system, those that deal with running the process, in other words just carrying the material from vessel to vessel, the materials of construction of each process vessel, so forth and so on, and then those that are dealing specifically with the product.

In all there's 46 start-up tests, of which 18 are directed specifically to the product. These range from product control demonstrations through those that deal with temperature profiles, as well as demonstrating that our reporting systems actually work. These of course are the ones that are of most interest I think to the board.

We'll talk a little bit in the next hour about the start-up tests that deal with the product control demonstrations, but I thought I would say a little bit about the testing for foreign materials that will go on.

We have developed some very specific equipment and systems to allow us to determine what the foreign materials are in the canisters, looking for organics, looking for water, sampling the atmosphere above the canister.

We'll have a puncture assembly which I'll show you in a moment which allows us to go into the canister without perturbing the atmosphere of the canister. This is hooked to an evacuated line. We measure pressure, dew point, we can pull samples off at the same time, we have different types of sampling, and we can send it to a mass spectrometer to analyze all the species and the vapor in particular. This looks like a superior way to find organics, even though we don't find any organics.

The canister puncture system is shown here, and this is really the key part of the whole thing because this is what allows us to get into the canister without changing the atmosphere in there.

What we have are canisters with basically a hole on the side, or a membrane if you will on the side which we then come down with a ram, punch it open and then pull into the rest of the system.

In terms of -- I won't say schedule, but overall logic of how we're going to proceed I've shown that on this, or tried to show it on this slide for you.

We're going to produce as many of the WQR volumes, at least in the initial form or preliminary form as possible, in part because some of these early ones, in particular Volumes V and VI that deal with the product consistency or glass durability specs really are necessary for approval to go on to qualification runs in other words the start-up test program portion that deals with acceptance of our product.

During the qualification runs then we'll update each of those initial volumes as well as be bringing in some additional information.

Then when we're ready to go to hot start-up those specifications or those volumes that deal with our ability to handle radioactivity, for example reporting of the radionuclide inventory, all of those have got to be in place, we've got to have those systems in place when we go on to production.

Then after production begins, for example we'll be doing extensive sampling on the first batch at least, glassing of the product. That information will go into an updated version of Volume V.

We'll also then start talking about things like, you know, smearing the canister, measurement of the canister level by the Gamma level in the glass, things that you can't do unless you've got the radioactivity there, and then later on we'll deal with some of the transportation issues leading up to a shipping facility.

So to conclude this portion of the talk, we have developed detailed strategies which we believe will ensure that we're going to consistently make a product that meets our specifications.

We're carrying out multifaceted demonstrations to show that these strategies will work, and by that I mean product plan, hot cell, laboratory bench as well as full-scale in the facility, all showing that the things that we're saying out to work in fact do work in the real world.

However, we have to be honest and say that really the start-up test program is going to be the key, because that's where we're going to demonstrate day in and day out, canister after canister that we can make and will make a product that meets the specifications.

I started by talking about diversity. I think this program as you've seen does span a wide diversity of technical disciplines -- material science, metallurgy, computer science, chemical engineering, ceramic engineering. It's a good program, we believe in it and we think it's going to do the job it was intended to do.

I think before I go on I would be glad to entertain any brief questions if you'd like.

The next two talks by Sharon Marra and myself are going to talk about the glass product control program.

What I'm going to do is I'll first talk about the technical bases for that program. Sharon Marra will then talk about the program itself, and then I'll get back up and talk a little bit about the qualification testing that will be done in the facility and give a conclusion.

Again, the specification we talked about before, control the process so the glass is better than the EA glass by at least two standard deviations.

Volume V of the WQR describes the strategy and the technical bases and the qualification test. That' what I'll be talking about.

The key points there of course are the control of the feed as the way to do the job, that we will do occasional glass sampling to confirm that we've made a good product, and then we'll report on the basis of the macro-batch.

Volume VI, the glass product control program itself, is the implementation of the strategy, and is the embodiment of the technical bases if you will in the facility.

Just sort of summary of what I'm going to tell you, the key parameter we've got to control is the glass composition. We can best control that through control of the feed composition, and that's best done in the last feed preparation vessel.

We're using the free energy of hydration which I'll talk a little bit about as a way to evaluate the composition, and it appears to be very useful in doing that.

And we've embedded this method of looking at the feed composition in a software system which allows us to assure that we're going to get a good quality product, while at the same time satisfying some very important processing constraints that we have.

If you look at leach testing in general, or the PCT in particular, the performance of the glass on a test is going to be a factor of the -- or is going to depend on the factors shown here.

Any good test is going to fix many, if not most of those, in our case the PCT fixes, all of those with the exception of the glass composition. Therefore, in order to meet the specification we have to control the glass composition. That's the key variable.

So that means that we have to be certain that the glasses we're going to make before we start out in fact will meet the specification. As I told you, we had got samples of each of our projected glasses from Corning Glass, and what we've done here is to compare the PCT results for those glasses against the PCT results of the EA glass, and you can see even for our worst case glass there's about a factor of five to six difference between the specified benchmark glass and the results of the worst case glass, so we'll make -- we should be able to make a product that will meet the specifications.

The key then is to control the process so that we always make the product that we want to make.

I'm going to condense down thirty minutes of Clyde Terrell's talk into about two seconds of mine, and invite you to think of our process in a much simpler manner.

What we have out in the tank farm can be thought of as two types of material. One is the insoluble material, the sludge which has almost all of the long-lived hazard, perhaps, three, four, times worth of the long-term hazard.

In the soluble portion of the waste the only really hazardous species is the cesium, and it contains about 95 percent of the cesium, in particular cesium 137.

These then are treated out in the tank farm, they come into the facility, they go through a feed preparation step where we do some massaging of them and mix them with glass forming chemicals in the form of a premelted frit. That's fed through a melter, poured into a canister, and the canister is sealed and closed. That's the DWPF process in a lot less detail than Clyde gave it to you.

I think the real key that I want you to concentrate on is that basically we've got three components that we're trying to bring together.

Now, we're going to control glass composition, or we want to control glass composition. We want to make only glass that meets the specification. We want to be sure that you don't get it until we've got it right, and there are certain drivers that lead to some very important effects if you will in terms of our program.

First we really cannot practically speaking recycle bad glass. We've got to have as close to a zero defects process as is humanly possible.

What that means is the glass sampling is of very little importance in terms of making a good product. It may help convince you that I've made a good product, but it won't do anything for me in making a good product.

That means that I've got to exert my control before I've made it into glass, so I've got to control the feed composition in order to get the glass composition that I want.

Now, we also want to maximize the effectiveness of the control, we want to really control this process extremely tightly, again was a zero-defect process if at all possible. That means that we want to control on the finest possible scale that we can. In other words, if we control every little bit, then the big bits will take care of themselves if you will.

The way to do that is since the material goes through in slugs, through the process in slugs of about six to eight thousand gallons which we'll call a process batch, that we need to control each and every process batch.

At the same time we want to have very tight controls, we want to make sure that we don't undo those controls once we've put them in place. What that implies is that we want to apply that control at the last possible minute, or if you will after we've done all the variations or made all the additions to the feed that we're going to make, so that means that we're going to make those adjustments at our last feed preparation vessel which is called the slurry mix evaporator.

There are some other constraints that we have to address, though. First, our waste is variable in composition out there as I've alluded to previously, and our future waste compositions may be very different from what we have today. They may in fact be very much closer to what I showed earlier as the HM process material. If we were running a graphite-cooled reactor in a new production reactor it would be something altogether different. We just don't know and cannot tell you right now what they're going to be, but we want our process control scheme to be able to handle these variations.

At the same time we want to minimize any needless shutdowns of the process. One way to look at the DWPF is that its primary purpose is to get the waste out of the tanks and into a solid form, so there's a real driver to keep this process up, keep it moving, but at the same time we don't want to make bad stuff. We want to make a good product that RW can handle and put in the ground.

Now, what that means is that we need a tool that's going to allow us to evaluate compositions of feed in terms of the glass that they're going to make which is easy to use, which is reliable and we can use during production, that a production specialist in fact might be able to use.

The tool has got to be able to take into account waste variability, effects of trace components, and it has to be able to do that consistently. And again because of the wide range of materials that we're going to have to be dealing with we want to have a wide range of applicability, both according to the composition of the glass and the test conditions that we might run.

As I mentioned, the previous set of specifications had another leach test. Now we're using a PCT. Some day in the future the repository program may prefer something more site specific. We would like our process control to be amenable so we can say that we have controlled it and it will be good under no matter what conditions they test.

Previously we had been using an approach based on hydration thermodynamics to look at glass and glass composition, and it looks like it may fill the need for this pool.

We assume that the glass is a mechanical mixture of components such as silica, B203, so forth and so on, and each component has a well defined free energy reaction with water. In fact, you can look these up in tables, standard tables.

We then make the assumption that the free energy of hydration of the glass with the free energy of the reaction between glass and water is equal to the sum of the free energies of the individual components weighted by the amount of that component in the glass, and that's what's shown in this equation.

This allows us then to take into account trace components, it gives us a well defined mathematical formalism that we can deal with.

I have included the basis set if you will of components in your package of slides for your edification.

We'll gloss right over those quickly.

One of the reasons why we like it, like this approach is that we can correlate a lot of data with it. What you see here is the free energy of hydration calculated from the glass composition. The units here are kilocalories per kilogram, and I have shown the boron release to solution. This is preliminary data, we're getting a lot more.

We had done similar work for the MCC-1 test which was the previous specification. You can see here we have a much wider range of glasses that we've tested under that test range, test conditions, and you see that there's good prediction between the model or the approach, free energy of hydration approach, and the release over about four decades, this release from silica on that test, and not only for waste glasses but for a wide variety of different kinds of glasses, both natural and man-made.

We also applied this approach to glasses, waste glasses that had been buried in the granite Stripa for two years. These glasses were buried at 90 degrees C under the relatively uncontrolled conditions down in the ground. This included both our waste glasses as well as French waste glasses.

Your commercial for today, this is a DWPF glass that was down there, and is indicative of the kind of glass that we'll be putting out.

We also found that there was a very interesting series of tests were going on, and had been going on in Ballidon in UK where they had buried both synthetic and museum pieces glasses in clay. We were fortunate enough to through the good offices of the University of Sheffield to get some glasses in burial in these tests, and you can see again we've used the free energy of hydration approach, and it agrees quite well with what we're seeing in terms of the extent of reaction between the glass and the water in that particular site.

I have included a few other examples in your handout, so I won't go over those.

We have a tool then that allows us to evaluate the glass composition in terms of its performance on the PCT, but we also have constraints that we must meet in terms of process safety, process reliability, and these constraints in some cases could drive us in a direction opposite from that of glass durability. Things such as corrosion, volatility, there are release limits on the facility.

Solubility of the waste. After all, we're running this whole thing to put the waste in the glass, we want it to be soluble in the glass that we're going to put it in.

What we needed was a system that would allow us to take into consideration each of these needs and put them on a common basis so that we could get a product that met the product needs as well as the process needs at all times.

Unfortunately, the specification itself on durability requires use of multivariance statistical process controlled algorithms, and as a result we need to get that into this same system in order to be sure that we meet the specifications.

What this system has to do if you will -- I'm doing a performance requirements here on one slide -- is that it has to define how we're going to blend these waste streams and the frit together, it has to have a way to evaluate how well we've blended them together, and then recommend how we're going to fix the blend if in fact we didn't get it right the first time.

That's what we call our product composition control system. What it does, it takes the set of desired properties which I've shown here -- liquidous temperature for example is a measure of the waste solubility, viscosity of course is related both to corrosion and to volatility -- all of these are in terms of the composition and the property. It then reflects those desired properties into desired compositions.

As I said, you can think of our process as blending these three streams which I've shown on a triangular pseudo-phase diagram.

So what the PCCS will do initially will be to take the compositions of each of these three components and define the target for blending. It will take into account not only the properties, but also the errors associated -- measurement, mixing, process variability and the property correlations, and that's what I've tried to show with the nested boxes there -- and get inside of all of those constraints to make sure that we'll meet all the required properties.

Then in the facility we'll blend that batch, and the PCCS will then be used to determine "What did we make? Did we make what we wanted?"

It will take the actual composition from the laboratory and use that as input, and then say "Okay, where exactly in this triangular diagram are we."

Now, we expect the overwhelming majority of the time we'll actually be within this area here, but if necessary, if we're not there the PCCS will tell us "All right, here's what you need to do to get back in there," and I've shown here most of the time what it looks like it will need to do is simply add frit. Frit is about 77 percent silica, it's good for durability, so what the PCCS will do then will be to define the remediation strategy that we'll have to follow.

Now, all of this is bound up into a glass product control program. Initially what we'll be doing is when we get a batch of feed will be to determine its composition out in the tank farm, checking whether the frit composition that we have on hand will in fact produce a glass that is good, and thereby allowing us to if you will qualify that waste for DWPS processing.

Once we get material then into the facility, we'll be analyzing that feed, passing it through the process. When we get to the last feed preparation vessel we'll hold that material until the PCCS says yes, it's all right, and we'll pass it forward.

As I like to say, no glass will be made before its time.

We'll then pass that good feed forward to the melter, make glass out of it, pour it into the canister and then store it on site until the repository is ready.

Now, that in a nutshell is what our glass product control program is, but Sharon Marra will tell you in a lot more detail the nuances of it.

MS. MARRA: John has given you a good description of the technical bases of the glass product control program. I'm going to try and talk about the steps that the DWPF will take and how they will implement this program, and not only actions that will be taken but the organizations that will perform these actions.

As you saw in John's last slide which touched on the elements of the program, the first one being the qualification of waste, and this will be performed by the Savannah River Laboratory, or SRL as we call it, for the DWPF. They will take actual waste samples from the tank farm, bring them up to SRL and actually make glass with them and characterize that glass to ensure that we'll be using the correct frit composition at DWPF and that that particular waste can be processed through the vessels and the tanks and all the equipment in the DWPF.

The next steps on the list move into the actual DWPF, into the slurry mix evaporator which as you've heard before is the last feed preparation vessel, and this is actually where we'll control the glass product by controlling the chemical composition of this feed material.

The SME will be sampled and analyzed, and acceptability will be determined by the product composition control system, or PCCS, before it is passed forward to the melter feed tank, and from the melter feed tank it's continuously fed to the melter.

If the PCCS does determine that the feed is unacceptable, it can be adjusted, and it will be adjusted before it's passed forward to the melter feed tank.

Occasionally we will take glass samples from the glass pour stream, and this will confirm that an acceptable glass has been produced.

And finally in the production records which will be sent to the repository with the canisters we will verify that a consistent glass product has been produced by using results from analyzing the feed material as well as any glass samples that were taken.

Before I go further into the program, as you probably can tell the DWPS is essentially a batch process, and so there are several different types of batches that we refer to. John touched on the macro-batch concept which essentially is a consistent feed to the DWPF, so a macro-batch will feed the DWPF for approximately four months.

The process batch is a portion of that feed material which will pass through each process vessel. Essentially it's down to six to eight thousand gallons.

The SME batch -- when we refer to SME batch we just refer to the material that's in the SME, and this is the material that has been transferred from the SRAT or the sludge receipt adjustment tank, and any remaining heel that's in the SME from the previous batch.

The MFT batch being the same thing, the material is transferred from the SME and any remaining heel that's in the batch.

One thing to keep in mind is the macro-batch yields approximately thirty process batches, and approximately 120 canisters, so when we refer to a macro-batch that's the equivalent of approximately 120 canisters of glass.

This is a similar type slide which shows the process and shows the sampling points that are important to the product control program. As you can see, we'll be sampling the precipitate and sludge feed in the tank farms, and this will be used for the qualification of waste which will be performed for DWPF by SRL.

Then we move on through feed preparation tanks and on to the slurry mix evaporator, and each SME batch will be sampled before it is passed forward to the MFT. It will be analyzed, and the PCCS will determine its acceptability based on the technical details that John gave you earlier.

Once it's determined to be acceptable, it is passed forward to the MFP, and from there on to the melter, and occasionally we will take glass samples from the glass pour stream.

Each MFT batch will be sampled as well. I'm not going to go into detail with that, but that's important for reporting the chemical composition and radionuclide inventory.

Since I'm going to focus on what organizations will be performing these activities in the DWPF I just wanted to show you a brief organization chart. DWPF is made up of seven departments -- the ones we'll focus on for this program are mainly the technical and engineering department and the operations organization which is part of the plant management department. This organization actually runs the process and they'll provide the data for the production records.

The quality assurance group will oversee the QA program for high-level waste form production, and you'll hear more about QA from Bill Pearson in a little while.

The start-up organization manages the start-up test program, and again you'll hear more about that from John Plodinec after I'm finished.

The process cognizant engineering organization which is part of the technical and engineering department supports the operations group on a day-to-day basis, and they're the group that will be operating the PCCS.

The analytical group is also part of this department, and they actually take the samples from process batches as well as analyzing those samples.

The waste acceptance group which is part of the regulatory compliance organization, they represent the product for the DWPF. This group will ensure that the DWPF will comply with the waste acceptance preliminary specifications, and they will cosign the production records.

Along with the glass technology group which is part of the Savannah River Laboratory, this group will be responsible for all the work that's done in support of this program at the Savannah River Laboratory, which includes qualifying the waste, recommending sampling regimens, confirming that we're using the correct frit composition, and characterizing glass samples, and as I said they will co-sign the production records with DWPF's waste acceptance group.

The first element of the program is qualification of waste, and I've tried to show it on this flow chart where all the analyses are coming from and who's performing them and how they're doing it.

As you've heard, the three components of the macro-batch are the sludge, the precipitate and the frit. As I said, SRL will sample the sludge and the precipitate from -- they will receive samples from the tank farm of the sludge and the precipitate, and they will analyze these samples.

The frit analysis will come from the frit vendor as well as an independent laboratory, and all these results will be combined as part of the macro-batch.

SRL will then use the PCCS to define a blend composition. This composition will then be processed in SRL's shielded cells facility using actual waste from the tank farm as well as the actual frit that we'll be using in the DWPF.

The purpose of this will be to actually make glass and determine, or to demonstrate that the waste can produce an acceptable product for the DWPF as well as it being -- as well as to show that it is processable in the DWPF.

SRL will then prepare a report and transmit it to DWPF which will be DWPF's demonstration that this waste can be processed successfully in the DWPF.

I mentioned SRL's shielded cells facility. This is a picture of the melter that is in SRL's shielded cells facility. It's not an exact replica of the DWPF melter, but it will produce -- it works on the same principle as the DWPF melter.

Small canisters are located inside here, and then the whole melter is tipped to fill these canisters.

Another important study that SRL will perform for the DWPF is to study the variability of the batches that will be produced in the DWPF using simulated glass. This is the Batch 1 model which is the first one that will be produced in the DWPF.

Simulated samples of glass have been produced which surround the target composition which is a 64 weight percent frit, 36 weight percent waste composition, and compositions which surround this region have been manufactured and are being characterized to study what effects variability in the waste will have. This work is ongoing right now, and it's almost complete, and once this one is complete they will do the same thing for Batch 2, 3 and 4.

Now we move into what will actually happen in the DWPF. As we said, the slurry mix evaporator is the last feed preparation vessel, and that's where the process will be held until that batch is determined to be acceptable.

The SME batch is sampled and analyzed by the DWPF analytical group, and this analysis is used the cognizant technical engineering group in the PCCS to determine the acceptability.

If the PCCS does determine that the batch is acceptable, the operations organization will pass that batch forward to the melter feed tank and then on to the melter. However, if it's determined to be unacceptable it can be redmediated.

The PCCS will determine a remediation strategy and, as I said earlier, the PCCS is operated by the cognizant technical engineering group, and DWPF's waste acceptance group will also be involved in this decision to offer assistance as needed and to ensure that an acceptable glass product will be produced.

As I said, occasionally glass pour stream samples will be taken for confirmation that the DWPF has controlled the glass product.

I'll just show you a picture of the glass sampler. Essentially it's a modified canister throat protector that's placed on top of the canister during canister filling. When it's time to take a sample from the glass pour stream, the sample cup is pushed out to collect approximately 50 grams of glass, then retracted and remains there until that particular canister has been filled with glass.

Once the canister is completely filled, the throat protector is removed and the glass sample is removed from the sample cup and transported to Savannah River Laboratory who will analyze the glass sample from the DWPF.

SRL will look for uniformity. They'll perform the product consistency test, they'll analyze for chemical composition and for radionuclide content, and all this information will be reported in the production records.

This is a picture of SRL's shielded cells facility where the product consistency tests will be performed.

As John mentioned earlier, crushed glass is used, 100 to 200 mesh glass is washed and placed in stainless steel vessels with ASTM type water, and the vessels are then laced inside an oven for seven days at 90 degrees Celsius.

The final step in this program is verifying that we have control of the glass product. Several results are used to provide this verification.

The SME samples, the chemical composition of the SME samples on a macro-batch basis are used to project the PCT results, and this is done using the product composition control system.

These projected PCT results are then averaged over the macro-batch, so essentially we have thirty projected results over a macro-batch, and we'll average and take the standard deviation of that result, and this will be only part of the input to the production records.

The other part will be results from glass samples that are taken at the DWPF and analyzed by SRL.

PCT results from these glass samples will be collected, and the glass technology group will prepare a report that will be provided to the DWPF.

Then SRL's glass technology group and DWPF's waste acceptance group will take these results, the glass sample results as well as the results from the feed samples, analyze them, review them and sign them, and this is the results that will go into the production records for that macro-batch of material, again which is essentially 120 canisters.

I've just given you a brief description of the glass product control program which we've developed to ensure that the glass product produced by the DWPF will satisfy the waste acceptance preliminary specifications, and that we can document that these specifications have been met.

We will use this program during the qualification runs and refine it and determine if there's any problems, and these results will be reported in the waste form qualification report.

I think John will finish up now and explain exactly what we're going to be doing during the qualification runs.

DR. PLODINEC: Thank you, Sharon.

Just a few words about the qualification runs themselves. The objective of course is to demonstrate that the strategy and the program that Sharon has just outlined will work not only during normal production, but even when we stress the system, when we make it do -- take it to the limits that it's designed for.

In terms of designing our program for the qualification runs, we've accepted if you will as givens that glass durability is controlled by composition, and that composition is going to vary.

We have also assumed that we will have in place the glass product control program.

We also wanted to maximize the value of the runs.

These runs are going to be very expensive and time-consuming to carry out; we wanted to make sure that we got the maximum value out of each one of them.

We felt that the way to do this was then to vary the feed over the widest credible range, or the full design range if you will that the facility is supposed to be able to handle, first just under small changes.

This represents if you will the normal kinds of variation that you'll see in the facility. We do this simply by adding a tracer between the first and the second run, and then following the ingrowth.

Then we'll make some drastic changes both in the viscosity and the density both in the feed and the glass. First we'll decrease it, decrease the viscosity, increase the density, then we'll make the opposite change. One way to look at it is that basically what we're going to be going through is a sine wave in terms of composition and in terms of properties, first an increase in viscosity, then an increase in viscosity, again changing viscosity because this is the primary property dealing with mixing a material. We want to force the system to segregate if it's ever going to so that we know cold what's going to happen. Then we'll come back to normal or medium conditions if you will for the first batch of radioactive feed.

What we'll be doing is we'll be comparing the glass samples that we're going to take using the glass sampler that Sharon showed to both the contents of the canister and to the PCCS predictions of what should be in that canister.

In terms of the details of the characterization of those canisters, I've already talked a bit about the foreign materials characterization, I won't talk about that any more, but that's also a part of this program.

We'll also be looking at the welds, but in terms of the glass and in terms of the product consistency specifications we'll use the glass sampler that Sharon showed for each of the 124 canisters that we're going to produce.

We'll also destructively examine most of the canisters, about a hundred of them. Those that are filled during the periods of greatest change in composition and those that are filled at the end of the run where we're at something like steady state we'll characterize in detail -- we'll cut sections up, look at the canisters both up and down and across to get a very detailed picture of how that glass is changing.

The rest of the canisters we'll simply take a wall off of the side and then pull some glass out of the open window at that point.

The characterization of each of these glass samples will be -- as shown here, we'll perform the product consistency test on every sample, we'll look at the chemical composition, including the glass redox. We have shown that that can have an effect on the durability or the results of the PCT.

We'll also identify any nonglassy phases, non vitreous phases that are in the glass.

So in conclusion as far as product consistency is concerned, controlling the composition of the glass is the key. Our glasses are variable in composition, but they should meet the spec.

We've got a good detailed program in place to ensure that we're going to make the glass that we say that we're going to make that's going to meet the specifications.

Qualification runs are what's remaining, and they're going to provide the crucial evidence that in fact we can do the things that we've said we're going to do.

If I can close on something of a personal note, I would like to say with Newton that if I've seen far it's because I've stood on the shoulders of giants. Given my somewhat diminutive status it's more like if I see anything at all it's because I can stand on some good people's shoulders.

I'd like to though acknowledge two people in particular for their contributions. One you've heard from, Sharon Marra. I think she's done a super job of taking some rather incoherent guidance and pulling it together into a relatively seamless and well thought out program.

Secondly I'd like to acknowledge the good working relationship I've had with my counterpart in the plant, Sonny Gohlston. He has the unenviable task of carrying out the promissory notes that I've been laying around the country, and for that I thank him.

If you have any questions I'd be glad to try to answer them, and Sharon too.

CHAIRMAN VERINK: I see we're a little bit over time. We're scheduled for a break here, and let's break. It's now 3:25, let's start up again at about 3:40.

(A brief recess.)

CHAIRMAN VERINK: We are now ready to begin with the continuation. Bill Pearson from DOE will be the next speaker. Bill.

MR. PEARSON: It's going to be kind of hard to follow John Plodinec and Sharon Marra's presentations on process with their detail and excitement associated with that for quality assurance, but we're pretty excited about the quality assurance program, and let me tell you a little bit about where we are with quality assurance at the Defense Waste Processing Facility.

This is a slide we had last time I was up talking with you, we talked about the items on the left side of that slide, and now we're going to talk about quality assurance requirements and the program for those requirements on the right side of the slide.

In addition to the requirements that RW has, we in fact have a DOE order on quality assurance. That order translates into a DOE/Savannah River Site Quality Assurance Manual, SRS-1.

The quality assurance manual and requirements of RW-0214, Rev. 4 go into a document we call the Quality Assurance Program Description Document at Savannah River, DOE/SR 2000-6, that describes the quality assurance program as applied to glass waste form production research and development as well as the process for producing it.

The items that are tinted in yellow are DOE documents. The items that are slightly in gray are contractor documents, Westinghouse Savannah River Company. As you can see, Westinghouse Savannah River Company has to respond to the DOE order for quality assurance with a quality assurance plan. From that they have a quality assurance manual called their 1-Q manual, we'll reference it as 1-Q manual.

They also have to take into account requirements of 214 for glass waste form production, and they generate a quality assurance program description, the SW4-1.8 Rev. 5

manual, and those things for the contractor get factored into DWPF operations and glass technology groups implementing procedures.

The implementing procedures go on down to quality achieving procedures, so we look at procedures that people use to do the testing, the knob-turning if you would to achieve the work. As a result, the work is documented in the qualification reports, that's the stuff that John was talking about being done by Savannah River Lab right now, and eventually the production glass qualification runs information. When we start producing glass then production reports of course will be produced and shipping and storage records to go along with that.

What happens is the different quality assurance programs provide us with some basic requirements. There's 19, really 20 software controllers also in that group, so the program that we developed incorporates all these requirements, and when we do surveillances, audits and reviews we use a check matrix if you would that incorporates the requirements of the NQA-1-based site program and the specific requirements of RW-0214 when we're looking at things that affect glass waste form production quality.

In the waste form specifications it states that the quality assurance program shall be applied to all testing and analysis activities that provide information to be included in the waste qualification reports.

Now, these activities of course include the things that John talked about from the glass technology group. They'll include DWPF start-up organization activities when we get into the melter qualification runs, analytical lab services that support sample analysis, suppliers, and then quality assurance oversight of the operations going on in DWPF in the lab.

Quality assurance for production operations from 0214 again as I said apply to those things which affect waste form quality. That's to differentiate, they don't necessarily apply to our security procedures, our maintenance of the general yard, but they do apply to those parts of the process that could affect glass quality, and we use a graded approach.

This slide is an attempt to describe the audit process, formal audit process that's used for those things that affect glass quality, used for verifying that we meet the requirements of RW-0214.

The QA program was developed with RW working with the Nuclear Regulatory Commission. As a result of that, of course they have given the enclosure requirements on environmental restoration waste management, EM headquarters who we're under at Savannah River.

So RW audits EM headquarters. EM headquarters audits the DOE Savannah River QA program. The DOE Savannah River QA program right now audits Westinghouse Defense Waste Processing Facility Operations Group. We also audit Savannah Laboratories research and development activities.

Now, this research and development activity audit is different in our eyes from Savannah River Laboratory's process support that they provide to DWPF.

Right now we are currently auditing this program. Savannah River Laboratory Glass Technology Group has in place an RW-0214-based program, and we have an evaluation assessment plan that schedules audit, surveillances and reviews of that program to 0214.

We are currently, Savannah River, doing audits of Westinghouse Defense Waste Processing Facility operations production group. They're in the process of putting in place a 0214-based program, I'll get into that a little bit later on, and then this audit process shows that Westinghouse audits suppliers and support groups for them.

Okay. In summary, going over the current status of the QA program, DOE Savannah River has in place a quality assurance program description, and it has been revised and is updated to Rev. 4 of RW-0214. We do understand that RW-0214 will soon some out with a Revision 5, and we will work to incorporate the revisions of the new programs in a timely method.

In addition to the quality assurance program description, DOE Savannah River has fifty implementing procedures in place that it uses to satisfy the requirements of 0214 for its quality assurance oversight and its program management of the Defense Waste Processing Facility.

Currently DOE Savannah River as I mentioned is performing surveillances and audits of the operations group and the glass technology group in the laboratory.

I also want to mention that the NRC, RW, State of Nevada have participated as observers when EM headquarters has come down to audit DOE Savannah River quality assurance program. We found that very helpful to us at Savannah River to understand different interpretations of 0214 requirements.

In addition to that I might add that EM is participating quite often as actual auditors in audits that DOE Savannah River is doing of the operating contractor. We use our evaluation assessment plan to schedule those audits reviews, and headquarters builds on our audit evaluation plan to come up with their own audit evaluation plan to participate in our audits of the contractor.

Also as I mentioned, Savannah River Laboratory glass technology group does have a program in place implementing the 0214 for the research and development efforts, the efforts that John has talked about that are ongoing right now, and we have them scheduled in our evaluation and assessment plans and do audits and surveillances and reviews as scheduled on their activities in the QA program.

I guess I want to point out the important item on this slide is that Westinghouse Production Operations Group, the group that will be running the process out there to make glass, running the melter if you would, are currently developing their quality assurance program 0214.

All right. There is a site QA program that is in effect, though, for the 10 percent that doesn't quite meet 0214.

Since that group right now is not into qualification runs where we're running the melter, taking information that will go into the qualification report, we feel that it's all right that they run under the existing site program for that additional 10 percent that's not covered, but they've committed to have in place by 3 of '92 a program that meets 0214 to cover the vitrification activities. We plan to start vitrification or qualification runs of the melter in July of '93 right now, so that will give plenty of time for them to have the program in place, for them to do their assessments of that program, and then for DOE Savannah River to in fact review it and ensure that the program is in place to meet 0214 before we take data from the cold test to put into the qualification reports.

That kind of summarizes the quality assurance program that we're using right now at DWPF.

I guess I need to make one statement yet if I may. For those who are coming on the tour tomorrow, we do plan to have the vans out front at about 6:45 in the morning. We kind of need to leave just about right at seven o'clock because it's quite a drive out there with the traffic in the morning, and we've got quite a long day planned, and I understand some people have to be back here no later than five o'clock.

VOICE: Clothes, special clothes or anything.

MR. PEARSON: Good point. Please be casual, very casual, very comfortable shoes, comfortable clothing. If you have jeans, wear jeans, that's fine. It makes it much easier moving about.

And no cameras. I believe everybody has heard that, we don't allow any cameras on site, so you would need to check that with your luggage maybe here at the hotel.

CHAIRMAN VERINK: The next item on the agenda is a continuation of the question and answer period which was initiated this morning, and the floor is open for any questions that anyone would have, first from the board.

DR. PRICE: I'd just like to ask the last speaker about computer software QA.

Could you expand a little bit about how you QA computer software?

MR. PEARSON: I can go into it a little bit, and I think I can get some additional assistance from some experts that are here with us.

We have some software that we're going to consider as essential software that could in fact affect glass waste form quality. We plan to control that software by using our document control process and applying it to the software, and when the software is put in place and is verified then changes to it have to be reviewed and controlled and verified so that we know and the operations knows the basis for any changes in the software and that the software is properly maintained.

DR. PRICE: Do you require modularization of the codes so that you can label parts of it as critical or whatever your terminology is?

DR. PLODINEC: The code in particular that Bill was referring to is the PCCS, which we and the Savannah River Laboratory are the developer for the DWPF.

We have performance requirements from the DWPF that spell out what the code has to be. Those requirements did not spell it out as modular in the sense that you're referring to. Basically it said what the code had to do. It turns out that the code itself is modular because of the particular software we're using and what have you, but that was not a requirement.

In effect our general view has been that if it's part of that system and we're using that system for compliance with the specifications then that entire piece has to be controlled.

DR. PRICE: While I've got you on the line, could I ask you, you showed a number of linear fits for your PCC backup. Could you supply R squared values or R values or some goodness of fit data for those? I imagine they're in the articles that they came from.

DR. PLODINEC: Yes, I could. Would you like me to give them to now?

DR. PRICE: Well, if you have them, but --

DR. PLODINEC: Well, basically the one I think would be most meaningful would be the one that's on the MCC-1 because there we have an extensive body of data, and there the goodness of fit was on the order of about .7 to .8.

The PCT, we're still in the throes of developing or testing the algorithm versus composition, and we're probably about two months away from having that completed. The data that I showed you had an R squared again of about .7 or so.

The in situ test -- really the R squared is not all that useful a measure there, but in general it's not as good, it's on the order of about -- almost .7 again, .65 or so.

CHAIRMAN VERINK: Yes.

DR. REITER: I have a question that sort of bridges this morning and this afternoon, it's really a question.

This morning I think Peter Gottlieb told us about system studies for thermal loading that looked upon a whole range of assumptions, including how one configures the waste as one puts it in there, particularly the spent fuel, and this afternoon from John Plodinec we heard some very detailed descriptions as to what the waste should look like, defense high-level waste should look like.

I'm just wondering whether or not in the system studies is the variability of defense level waste, its configuration, is that an important input, and if it isn't an important input is there a flexibility in your program to vary that accordingly.

CHAIRMAN VERINK: Anyone like to tackle that one?

MR. CHACEY: Is anybody from RW, Steve Gomberg, is anybody here to pick up on that? because it really deals with defining some of the waste acceptance requirements and the envelope for that.

MS. HARRISON-GEISLER: I'm Diane Harrison-Geisler with the Yucca Mountain Project Office.

I guess for me to better understand the question, you were wondering maybe in the general sense if we're looking at including the configuration of the defense waste as part of our development of the engineered barrier system in the design?

DR. REITER: I guess Mr. Gottlieb made a presentation, and he talked about the system study and looking at thermal loading, and there are all kinds of sensitivity options, some of those options including various configurations of the spent fuel.

Now, we also know that part of the input, though small in part, is going to be high-level waste, and would that be -- is there some need for variability in that input to give greater flexibility to meet different thermal loading concepts? And if that is of some importance, is there enough flexibility on the part of the people at Savannah River to accommodate those kinds of things, or is everything cast in concrete here, or cast in glass?

MS. HARRISON-GEISLER: Well, I don't think we're planning on imposing any criteria on DWPF and that side of the house. What they are giving us is a given so to speak, just as the spent fuel is, and it is a very small portion of the waste form that we're retrieving.

As to whether or not that's being incorporated into the system study, I'm not 100 percent certain on that.

DR. REITER: Excuse me. The spent fuel is not a given, and from what I understand one of the options we're going to be looking at is universal casks. I mean there are various configurations, and is the variability needed, and if it's needed is it there?

MS. HARRISON-GEISLER: I guess I'm just misunderstanding.

DR. PLODINEC: Let me answer the back end of the question maybe which might cut through it.

I think the overall program of the department, as Diane said, is based on the opinion that we're pretty much locked in. Again remember as I've made the point several times our facility was designed and almost completely constructed before we had any specifications from repository program.

In terms of the envelope, by which I mean the canister and its size, we're locked in. We cannot change that.

As far as the loading of material in the glass, in other words the heat and what have you, in principle we're not. In practice we're almost locked in that what's really going to control that from our standpoint is the shielding in the facility, so we can't go very much higher than our design base is. We could go lower, but that would require more canisters, hence more cost, and undoubtedly that would be yet another point of negotiation as far as the nuclear waste fee is concerned.

CHAIRMAN VERINK: Does anyone have another comment on this?

MR. COLES: This is John Coles from TRW M&O.

Peter did mention in his talk this morning that as part of the strategy of emplacement partially filling it and maybe coming back in again that they were considering using the glass in certain of the locations and alternating it with the civilian waste as part of the strategy, so as they are spreading the waste into the repository they are considering both types of waste.

DR. PRICE: Could I follow up with just kind of a general question?

To what extent is the canister Yucca Mountain-specific and to what extent do you see that it could be used regardless if the site were Yucca Mountain or not?

DR. PLODINEC: Well, I think the department's position, if I may be so bold as to speak for them, is simply that our canister is if you will a receptacle for the glass that allows it to be taken from our facility to their facility, and to be emplaced wherever they want to put it.

Originally as you may know, there was serious consideration given for Yucca Mountain to take credit for our canister. It's my understanding that that decision went the other way, in other words they decided to overpack primarily because of the questions of the long-term viability of trying to take credit for all the QA that we do on our canister, but of course then we fill that canister and it's going to sit there for a very long period of time, we're in a gray zone when it comes to materials or performance questions as far as provability of the performance of those materials.

I think everybody knows that there's no problem, but proving there's no problem is another story, so the decision was made "Okay, in terms of speeding the licensing process let's not take credit for the canister, the pour canister, let's put our own overpack on it specific to the particular site."

MS. HARRISON-GEISLER: This is Diane Harrison-Geisler with the Yucca Mountain Project, Department of Energy.

I wanted to really clarify that. The high-level waste canister is not specific to Yucca Mountain. I think that the stainless steel container was chosen because that material is very well known and very well characterized and very well understood, but it is not specific to the Yucca Mountain design at all.

Thank you.

CHAIRMAN VERINK: Any other questions from the board?

(No response.)

CHAIRMAN VERINK: Any questions from the audience? Pardon me. Do you have a question, Russ?

MR. McFARLAND: Russ McFarland, TRB staff.

To go to a general question, my limited background in vitrification, bear with me, but in reading some of the press, the journals, I understand there is a fairly significant difference between vitrification as practiced by the French and as practiced by the United States.

Could you offer some insight into this difference?

MR. CHACEY: Let me take the first stab at it, and then we can let John Plodinec or another person provide some of the technical details.

There is a lot of information and data available that's in the literature. For example, back in July of this past year they had an alternative feasibility study that was issued to Congress. About three weeks ago we addressed some additional questions that came from Senator Grassley's staff on the comparison both from a technology standpoint and from a cost standpoint of the French technology with our vitrification activities. That can be made available to the board if appropriate.

And then in terms of the specific details associated with the differences between those processes, a lot of it deals with the front end pretreatment associated with the different programs.

The French do not have a pretreatment process that they have to follow, they go directly from an acid waste right into their vitrification facility, so they can do process steps, or eliminate process steps that we would find it very difficult to do at this point because of our present form of a sludge waste with a supernatant cesium, a supernate waste.

So because we deal with a basic waste and the difficulty associated with trying to turn that back into an acid type of waste there are some front end problems with using that technology.

There's also some problems associated with the throughput. If you were to scale up their process to meet this 100 kilograms throughput design for DWPF for example there would be -- when you start comparing the cost of those, depending on what calculations you use they are reasonably similar.

So there's no real advantages identified at this point for trying to adopt that type of technology into the DWPF program as far as they are along with design and construction and start-up.

We are, however, looking at improved design technology, including a Stuart-Milder technology to try to improve the capacity and throughput, and also some technical problems associated with the current DWPF and Hanford and West Valley melters.

The French technology is being used in various forms, but also the LSCM or the liquid ceramic fed melter is a process and technology that's used by a number of countries as well.

John, did you want to add anything to that?

MR. PLODINEC: Yes, just real quickly.

It just so happens that the tests I referred to in Stripa in my talk, if you remember this was the DWPF glass, these two glasses are French glasses. This is roughly comparable to what the EA glass would do.

In other words, our benchmark is roughly equivalent to their production glass. What we'll actually make should be better.

I think an important reason for that is the fact that they don't mix their feed as we do. We take great pains to make sure that everything is well homogenized before it ever gets to the melter. They -- the best you can say is they mingle their feed together, and as a result their glass has a lot more nonuniformities in it than ours does.

I think all of Ken's points were well taken as far as size of facility, more process lines needed than the technology we're using.

MR. McFARLAND: Thank you.

CHAIRMAN VERINK: Are there any other questions or comments?

(No response.)

CHAIRMAN VERINK: Hearing none, then allow me, please, to offer my special thanks to the participants in the program, and to DOE and SAIC and TRW and Westinghouse, and those who have responded to questions and who have raised questions, all of whom helped make this a little more vital sort of an exercise.

Thank you again, and we'll see you one of these other times.

(Whereupon, at 4:15 p.m. the meeting was concluded.)