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NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON NUCLEAR WASTE

Title: **MEETING: 119TH ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW)**

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LOCATION: Rockville, MD

DATE: Wednesday, June 14, 2000 **PAGES: 98 - 291**

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ADVISORY COMMITTEE ON NUCLEAR WASTE

JUNE 14, 2000

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON NUCLEAR WASTE

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119TH ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW)

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Nuclear Regulatory Commission
Two White Flint North
Room 2B3
11545 Rockville Pike
Rockville, MD 20852-2738

Thursday, June 14, 2000

The committee met, pursuant to notice, at 8:34 a.m.

MEMBERS PRESENT:

B. JOHN GARRICK, Chairman, ACNW
GEORGE M. HORNBERGER, Vice Chairman, ACNW
RAYMOND G. WYMER
MILTON LEVENSON

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P R O C E E D I N G S

[8:34 a.m.]

CHAIRMAN GARRICK: Good morning. The meeting will now come to order. This is the second day of the 119th meeting of the Advisory Committee on Nuclear Waste. My name is John Garrick, Chairman of the ACNW. Other members of the committee include George Hornberger, Ray Wymer and Milton Levenson. This entire meeting will be open to the public.

Today the committee will first hear from representatives of the Department of Energy on the status of the design for the proposed high level waste repository at Yucca Mountain. We will discuss the evolving Revision 4 of the Yucca Mountain repository safety strategy, hear a briefing on Yucca Mountain's specific siting guidelines, 10 CFR Part 963, review the status of the NRC's low level radioactive waste program with representatives of the staff's Uranium Recovery and Low Level Waste Branch and prepare reports and letters on such topics as:

(1) risk-informed approaches to nuclear materials regulatory application;

(2) comments on the NRC's plan to provide sufficiency comments on the Yucca Mountain Site Recommendation Consideration Report;

(3) comments on DG 1067 and 1071, Decommissioning Regulatory Guides;

(4) comments on the Low Level Waste Branch Technical Position on Performance Assessment;

(5) highlights of the visit to the U.K. and France by the ACNW and staff; and (6) hear discussions with Divisions of Waste Management staff regarding the NRC's policy to decommissioning the West Valley Demonstration Project.

Richard Major is the designated federal official for the initial portion of today's meeting.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act.

As far as I know, we have received no written statements from members of the public regarding today's session, and, as usual, should anyone wish to make comment, please contact one of the committee's staff. And we suggest that each speaker use a microphone, identify themselves and speak with clarity and volume so that they can be readily heard.

Okay. The member of the committee that will lead the discussion on the first part of the Yucca Mountain material, and we will be talking Yucca Mountain essentially all morning, the committee member will be Milton Levenson. So, Milt, I am just going to let you take over.

MR. LEVENSON: Thank you, John.

We realize that the design of Yucca Mountain is still in a significant state of flux and that some of the things in the way of design may be firm, some may not be. We want an update at this time. I think it would be helpful to the committee if you could differentiate for us what aspects of the design are concepts that you think you will be staying with and what parts of it are details which may be getting revised between here and the license application time.

There is still a fair amount of time and I would hope that we might benefit from some of the experience of, say, the WIPP project, where they locked in very early details on, in this case, a shipping container, and once they had their license, they found that they had an almost impossible design to build, and I think they are now on their twentieth amendment to the license, and that is not a helpful thing for either the licensee or the regulator. So, I, for one, would encourage you to make a best effort to get a design, but one that is practical and one you can live with.

With that, I think we would like to hear what you have to say.

MR. HARRINGTON: I am Paul Harrington of the Department of Energy, I am the engineering lead for Yucca Mountain.

The intent today was to do several things, talk to you about the design changes, but not really to go through an elicitation of hardware, but to also talk about what it means to us and why we have the flexibility that we think we ought to have. This is, in part, driven by some of the concepts we went through when we did the enhanced design alternative study and came up with enhanced design alternative 2 as a recommendation. One of the reasons for that was the flexibility that that particular design offered.

We are making use of that flexibility in several different modes now, operational modes, ability to react to higher thermal content in waste packages, so, I think that is valuable.

Also, I will talk about the uncertainties from the thermal concerns that we and others have, now that is driving the design process. If you have questions that go to the process itself, I may defer those to Dr. Brocoum or Jack Bailey, they own the process. My interest is in primarily how that affects the engineering.

And, lastly, talk about the operating flexibility concepts. We have realized that many of the discussions that we have had regarding above-boiling or below-boiling repositories are not mutually exclusive. The concept that we have now, we think has sufficient flexibility that, by turning some knobs, we can accomplish either goal, accommodate either concern.

In the subsurface area, I have to apologize, I didn't put graphics in many of these first several pages. If you do want to flip to page 25, there is a layout of the current subsurface. I will talk to that more, obviously, when I get there, but just to give you a visual of what it looks like now.

The drifts have been reoriented. They had been 18 degrees above the east-west plain, as you go to the west, now they are 18 degrees below the east-west. We have also changed the ventilation shaft arrangement. It used to be, especially in the VA concept, that the supply was through the emplacement tunnel and exhausts were out through shafts through the top of the mountain. This current concept, because we have gone to the higher flow velocities, we have more modularized, so, now there are several sets of panels, five or six panels within the layout and each of those -- in fact, I will just go ahead and put that one up, each of those has its own supply and exhaust arrangement.

Within the upper block, this is the access ramp, the ESF, north and south portals, okay, this has been the basic development. You will see now that there is a supply and an exhaust system about every fifth of the repository. There is one set here, one set there, one set there, again and again. You will also see that this is extended to the south further than it had been before.

It used to be that there was a low point at the northeast corner and the repository continually rose as we went to the south. We put an inflection point in the middle, though, and now this slopes back down as you go further to the south. That is because the overburden slopes down as you go to the south. So, doing this, we were able to pick up additional area.

Also, you will see on the emplacement, or the supply ventilation shafts, there are cross-drifts that will then distribute the supply to either side of the emplacement drifts, the same collection through the emplacement drifts, the same drop from the emplacement drift down to the ventilation shaft underneath, and the same collection and exhaust that there had been. We have just done it a number of different panels now.

Question?

DR. HORNBERGER: Yeah. If we looked at this in cross-section, are these basically at the same level as the emplacement drifts? Above it, below it?

MR. HARRINGTON: These cross-supply drifts are. They will distribute air from the surface down and then to each of the sides of the mains. The ventilation drift here is about 10 meters below the emplacement drifts and they are connected by vertical risers from each of the emplacement drifts. That concept is the same as we have had before, but because of the increased flow rate, we needed a more distributed supply system.

Let's see, other changes, we are looking at the lower block now to accommodate larger inventories. I will get to that in that part of the discussion, but there is the general layout. So, the main changes are the expansion to the south, the panelization, if you will, with attendant supply and exhausts, there. The way we do that, doing that reorientation reduced some of costs of construction. It also had an affect on the size of the design basis rock.

Now, one of the IRSRs, one the KTIs with the NRC, it was the subsurface design, and in there we talk about rock size. We had a technical exchange about a month ago where we went through why we did this. Now, it is important to note that the resultant largest rock, by the time you go out to the end of the tails, is still larger than we are using as the design basis rock, but the reason for that is the orientation of that rock, to get that large, has to have length down the drift greater than the length of an individual drip shield segment or waste package. So, all of that load from a rock that gets that long would not be taken on an individual drip shield or waste package segment.

Remove the backfill. Okay. That came about in January of this year, that was driven by our realization that the input waste stream had changed. Earlier in '99, the M&O redid the waste throughput study. In there, there were two major factors. One was the removal of a hypothetical interim storage facility, which resulted in the average age of the fuel being a couple of years younger than it had been presumed to be earlier, and, also, the fact that the utilities will go to higher burnups that the earlier study had assumed.

So, due to the higher burnup and slightly lesser fuel life, there was a higher thermal content in the fuel assemblies, primarily for 21 PWR packages. Consequently, the average thermal content of the 21 PWRs went from 9.8 kilowatts to 11.3 kilowatts per package. The maximum that we wanted to have for a waste package was 11.8.

So, moving the average up that much caused some thermal problems. We had problems meeting the thermal goals of 350C on the cladding, of 200C on the rock, and, also, having a reasonable preclosure period, especially when we are looking at what do we do to keep the ability to remain sub-boiling.

So, we went through several iterations of that, and in January decided that the most appropriate response would be to remove the backfill. That was effectively a thermal blanket. Backfill would have been applied at closure. It isn't something that is applied earlier in the preclosure life. But having that backfill prevented the packages from radiating heat and caused us a problem with that higher thermal load.

There were a couple of other options that we had looked up, but that decided that was the most appropriate.

Yes?

DR. WYMER: What do you mean by a reasonable preclosure period?

MR. HARRINGTON: We are looking for something that could be closed as early as about 100 years. Now, you have heard us talk about 300 years. The intent there was not to have a design that required 300 years of preclosure ventilation to be acceptable, because of the concerns over institutional control, others, but, rather, have a design that was flexible enough to be able to be closed reasonably early, and we chose about 100 years as that lower limit, or be kept open should people choose to do so.

Yes?

CHAIRMAN GARRICK: Excuse me. Now, what about the advantages of the backfill? What does that mean to you in terms of the loss of those advantages? They didn't put the backfill just because they wanted to put backfill, it was -- there were good reasons.

MR. HARRINGTON: We thought that the benefits of the backfill were outweighed by the problems that it created with respect to thermal management.

Now, part of the benefits, if I remember right, were that it would keep the temperature higher so that you would delay the onset of moisture on the packages. But the problem with the higher thermal content within the package was that the temperatures became too high.

So, because of that, it became more of a problem than the solution and we pulled it out.

CHAIRMAN GARRICK: As I recall, one of the other benefits was that it provided some protection against falling rocks, et cetera.

MR. HARRINGTON: Right. The drip fields themselves, initially the first concept out of the gate was that they would be 20 millimeters thick and corrugated.

As we've done more rock analysis, rock fall, we've determined that we can accommodate a rock fall without backfill with a drip shield that's only 15 millimeters thick, with internal stiffener ribs inside that drip shield.

CHAIRMAN GARRICK: You've made the point several times that with the flexible design, you have the opportunity to vary the ventilation. You have some control over the aging of the fuel, and you still have some control from a design standpoint over the spacing of the fuel.

Now, I suppose you did tradeoffs between backfill/no-backfill, and the aging control. Certainly you can control the thermal lode by what you put in the mountain. I suppose you did those kind of tradeoffs?

MR. HARRINGTON: Yes, and, in fact, some of the first cuts at resolution of this issue were to have further spacing between waste packages. There were one or two others, but ultimately because of the problems that those created in terms of additional space, number of waste packages, extent of drip shield, the cost of the titanium for the drip shield, we came to this conclusion of removing the backfill as the preferred alternative.

As we get to the back, there is some discussion on what it means to have additional space between packages. We can do that for thermal control, but there's a cost, obviously, associated with that.

A question?

DR. HORNBERGER: Yes, just a followup. Was backfill considered in your analysis in terms of the intrusion of magma into the drift in terms of a volcanic analysis?

MR. HARRINGTON: I can't answer that. Can someone else here, somebody from the Science side? Dr. Brocoum?

MR. BROCOUM: This is Steve Brocoum. Yes, backfill did add a benefit in terms of the volcanic scenario, which is a benefit we lose when we remove backfill.

One point I want to make on backfill: We're not precluding it. In other words, the design will not preclude it, and we will consider that again in the future if it's appropriate.

But the design we're going into the SRCR and ESER with will not have backfill.

CHAIRMAN GARRICK: One final question on backfill: Of course, in the WIPP facility, the backfill plays a very important geochemical role, because it provides some assurance of maintaining the pH within a certain well-defined range.

And that's important in the mobilization of the waste. Dos the backfill -- did it have any role with respect to geochemical role, for example, with respect to the establishment of the source term?

MR. HARRINGTON: We had a geochemical concern about backfill, and that's one of the considerations that was leading us to a selection of a particular backfill material.

I think that for that reason we were leaning toward the silica sand rather than crushed tuff, for example.

But as far as a significant beneficial feature in terms of geochemical performance of backfill, I don't know that we had assigned any particular performance to that.

CHAIRMAN GARRICK: Okay, thank you.

MR. HARRINGTON: We were just trying to make sure it wasn't a deleterious feature.

MR. LEVENSON: I have one question: You mentioned that one of the problems with the backfill was that it reduced radiation heat loss from the containers.

I'm having a little trouble identifying that radiation heat transfer would really be significant if the clad temperature is 350 and you've got a double-walled container. What's your surface temperature of your container?

MR. HARRINGTON: It was on the order of 250 C, somewhere in that range.

MR. LEVENSON: And so radiation cannot be the primary mechanism by which it's transferring heat. And the titanium drip shield you're going to add is, in fact, a reflector, and probably interferes with cooling of the container.

Has all of that been taken into account in your assumption that you're better off, heat transfer-wise?

MR. HARRINGTON: Yes, actually, as I understand it, the radiant transfer is the predominant mechanism.

MR. LEVENSON: Even at that low a temperature?

MR. HARRINGTON: Yes. There is very little conduction because of the minimal contact with the --

MR. LEVENSON: That's without backfill. With backfill, conduction would probably be the major transfer.

MR. HARRINGTON: Well, except the backfill would not be contacting the waste package directly.

It would be contacting the drip shield, so you'd still have to radiate from the drip shield -- or from the waste package up to the drip shield.

MR. LEVENSON: Did you ever have a concept of backfill without the drip shield? The question is, why do you need the drip shield if you have backfill?

MR. HARRINGTON: The drip shield was there to make sure that water didn't condense onto the waste package. It was an attempt to keep moisture off of the waste package, and provide a dry environment around it.

One of the concerns with having backfill on the waste package directly was the ability to hold moisture on the waste package surface.

MR. LEVENSON: But also the ability to channel moisture around the waste package.

MR. HARRINGTON: Yes, yes. Others?

[No response.]

MR. HARRINGTON: Okay, we pulled the backfill. That gave us back the cladding credit. One of the concerns that we also had on backfill was the physical act of emplacing it at closure.

Obviously, both the drip shield and backfill were to have been emplaced. You'd be working in an environment that you couldn't really send personnel into. You were relying on performance.

That was another more near-term personnel exposure benefit to pulling it out, obviously, removing dose in handling.

We've also defined the drip shield emplacement gantry concept. It really looks quite similar to the waste package emplacement gantry.

There is a set of rails on either side of the waste package, running down the sides of the drift, and either of -- we have actually about three gantries, one for emplacement of the waste package, one for emplacement of the drip shield at the end of the preclosure period, and another one for performance confirmation.

That one hasn't really changed much since the VA design approach. It's basically another gantry-mounted device that would straddle waste packages and be able to go down.

With respect to the waste package, the biggest issue is our success at causing stress corrosion cracking at Lawrence Livermore test facility, and then what that meant to us in terms of the design for closure lids.

The approach that has been taken for SR is to identify a third lid of C-22, as second of C-22, a third lid overall on the outside of the waste package. I'm sorry I didn't bring a graphic today.

It is this. I know some of you got a chance to see it beforehand. Basically, this brown outer section is the Alloy 22 shell.

There is a device now that's mounted to the outside of it with a groove in it, one on each end. That will be for lifting. I'll talk about that in a moment.

Inside of that is the yellow stainless steel structural material. There is a blue inner Alloy 22 lid, and a red outer Alloy 22 lid.

Now, because of the stress corrosion cracking concern, we decided we need to do a stress relief activity on the closure welds, not of the 316 stainless, but of the two Alloy 22s.

The mechanism for that, because we can't post -- heat-treat stress relief the closure welds, we can the rest of the vessel, so it's really only the closure welds that are in question.

We came up with the concept of laser painting the weld on the inner lid, and believe that will give us on the order of two to three millimeters worth of penetration of stress relief.

And doing a thermal stress relief by induction coils on the outer weld, there's a little device that's to fit over that weld and rotate around the lid. They could have done the entire lid at once, but the power requirements for that are pretty extreme.

The intent is to take this up to about 1100 C for about 15 seconds, and then cool it quickly. That much power was too much to try and do the entire vessel at once, so the concept is now rotated.

Admittedly, this is a complex solution, three separate welds to close a waste package with no shielding on the inside of the package means that trying to rework rejectable indications on any of the welds would be problematic.

So, one of the advances that we're looking at between SR and the LA, is how to simplify this. With respect to a site recommendation, we think this is technically understandable.

We think that we can make a case to show the corrosion resistance of multiple barriers. But from an operational perspective, for a license application, we would expect to have something simpler.

Okay, use of a trunion ring: This outer groove is designed to accept a section trunion ring to fit around each end of the waste package.

Now, the reason we did that was in the earlier VA design, there were skirts. The outer skirt of the waste package extended out past the inner lid of the waste package, and the lifting apparatus came in from each end and engaged the skirt.

Okay, we have decided in this line-loading concept to move the packages much closer together. Now they're about a tenth of a meter apart, end-to-end, and because of the change of the joint geometry on the end for the welding, there's no skirt and you can't lift it that way.

So, we need some other way to grapple the package, so the concept is to put a ring, a recessed ring on each end and to have a section -- and it may be bolted, it may be screwed in some fashion -- the two sections lifting trunion apparatus that would be assembled to the disposal containers in the surface facility prior to loading the waste package.

The waste package would be loaded and handled within the surface facility with those rings, and they would be used to lay it down onto a pallet prior to taking the waste package underground.

At that point, the lifting trunion rings would be removed, and the package would simply sit on the pallet. We would then lift and handle the pallet. We would not be handling the waste package directly.

That's the reason for that. Now, that poses some problems for retrievability. Obviously, we have to be able to retrieve.

The older design had three holes and the screwed extension, and the intent was to grapple into those holes, if we were unable simply to reverse the emplacement process for retrieval.

With this, the hole are gone, there is no extension. We're working to come up with some mechanism that would be able to in situ engage that ring recess there.

Let's see, a smooth surface drip shield, earlier concepts were looking for simplicity and drip shield concept by having it corrugated so that you wouldn't need stiffeners on the inside to the extent you would with a flat piece.

But trying to roll the corrugations and then form that into a U, caused its own set of problems, so we've gotten away from that.

The current concept for a drip shield is that it is a flat plate, weld into not quite a 180-degree V. There's a little bit of a slope to it, and it has a series of almost labyrinth seals, if you will, on the end of each section.

Yes?

DR. WYMER: To what extent have you experimentally tested these concepts?

MR. HARRINGTON: In the ATWS facility over on Lossee Road in Las Vegas, we're doing some drip shield segment or testing now. And they do have some conceptual drip shield models there with simulated waste packages heat inside of them, and some backfill on it in some cases, looking at moisture movement and drip shield performance.

DR. WYMER: So you've got some fabrication information?

MR. HARRINGTON: I think that the fabrication of those was so conceptual it's not particularly relevant to the real concept that we're looking at here.

DR. HORNBERGER: Are the stiffeners welded?

MR. HARRINGTON: Yes, yes. There are stiffeners welded to the inside of the U-shape above it and they are welded to the outside of the supporting skirts underneath it. Obviously you have a sketch there.

The emplacement pallet we talked about a little bit. The supporting pieces of that and dimensionally the pallet consists of two V-grooves, V-blocks with each block under each end of the waste package. Each block is about half a meter wide and each block is made out of Alloy 22, so there is no dissimilar metal issue.

The two blocks are tied together by stainless steel tubing. That really only serves a role during the emplacement and potential retrieval period. For post-closure those tubes don't serve any real function. The function will be taken by the Alloy 22 support pads.

Are there questions on the waste package before I go to the waste handling building?

[No response.]

MR. HARRINGTON: Okay. On the waste handling building itself, and notice this one is specifically flagged as potential changes between SR and LA, the reason for that is for the SRCR and for the SR itself the designed for surface facility will be very much the same as what we had in the viability assessment, a few changes.

The VA had three wet assembly transfer lines and two dry canister transfer lines. For the SRCR and SR there will be two wet assembly lines and one dry canister line, so we will have made a few changes to the access to the building but effectively it's very much the same as it had been in the VA.

When we talked last, you folks expressed some concerns about what does that mean to us in terms of worker risk, especially with the blending, the blending hotter and cooler packages to achieve these lower thermal goals, so for a license application we are getting ready to take a much closer look at that.

For a site recommendation obviously the focus is really on the subsurface facility, on waste package, on waste form, how that might interact with the site. Not as much focus was given to the surface facilities. For license applications certainly we need to put much more effort into that than we have in the past, so we tasked the M&O several months ago with doing a study to identify what an appropriate set of requirements would be for the license application design evolution for a surface facility.

This is a series of recommendations, of considerations that are in the analysis right now. This is certainly not final. The M&O hasn't even presented it to their own management yet. It has not been therefore presented to the DOE as a set of recommendations but I thought it appropriate to share it with you because it is insight as to where we may be going or are certainly considering going in a license application to simplify surface facility to give us a little more flexibility, reduce personnel exposures, those sorts of things.

CHAIRMAN GARRICK: Do you have any -- it's the wrong word but I'll use it anyhow -- interim storage capacity in the waste handling building?

MR. HARRINGTON: Inventory -- and yes, we do.

The earlier concept, about a year ago, was that when we first looked at blending we might need on the order of 5,000 MTU worth of storage to accomplish that. That is driven by the very narrow delta between the average 21 PWR of 11.3 kilowatts and the maximum of 11.8 kilowatts.

With only about 4 percent margin you need quite a bit of inventory then to be able to hit that average, so that looked at the time like it might mean something like 5,000 MTU worth of available inventory.

One of the concepts here is that we may not need to hold the maximum waste package thermal content at 11.8, so they have looked at moving it up to 13.5 kilowatts. What that did, because you then have about 20 percent margin between that and the average, it cut the amount of inventory needed for this thermal blending down to a few hundred, on the order of 500 MTU but, yes, there is some operational inventory to accommodate thermal blending and also for upsets of either incoming waste stream, if the transportation system stops for some reason, or if the emplacement system stops or the canister or assembly handling systems stop, yes, we do have some inventory to accommodate that.

CHAIRMAN GARRICK: Just one more question on that.

You talk about the aging as one of the parameters --

MR. HARRINGTON: Correct.

CHAIRMAN GARRICK: -- for which you have some flexibility. Is most of that going to come from the arrangement between the repository operation and the reactor sites, for example, and is the whole shipment process going to be coordinated with respect to providing some control over the thermal load?

MR. HARRINGTON: We would like to get to that point. At this point we haven't defined what an optimum receipt scenario would look like. Now it may be that we would want to try and load the hotter packages earlier so that we would have time then for them to cool during a ventilation period and save some of the older, cooler fuel from utilities until late in the emplacement period to offset some of the hotter fuel that would be being generated at that point, but we haven't yet really determined what an optimum scenario would be.

Right now in the standard contract with the utilities really is not a vehicle for us to define to them what would be sort of a DOE preferred waste stream. Effectively obligated to take whatever it is that they choose to send us. Now I think both we and they believe that some accommodation would be appropriate and can be made by both parties. I think we have the ball now to try and identify what a good receipt scenario would look like to us and then once we have that and agree that this is something we want to take forward we would probably then get with the utilities and see what arrangements we could make to have them accommodate that.

CHAIRMAN GARRICK: Yes. The thrust of my question is just how are you going to achieve age management and it seems as though the alternatives are to basically use the reactor sites as the interim storage site.

MR. HARRINGTON: That's if we have the ability to do that --

CHAIRMAN GARRICK: Yes.

MR. HARRINGTON: -- certainly that would be helpful. If, for whatever reason, we are not able to ever get there, and we did decide to do the aging of the fuel prior to emplacement, then that could be done at the repository facility.

MR. LEVENSON: One follow-on question -- what conceptually is the nature or form of this inventory storage? Do you just kind of store it in shipping containers? Unload shipping containers?

MR. HARRINGTON: No. The transportation casks we need to recycle -- to return them. For SRCR and SR that will be wet pool storage for the commercial fuel both BWR and PWR.

One of the notes here --

MR. LEVENSON: You are going to be putting back into wet storage fuel that has been dry stored for a number of years?

MR. HARRINGTON: Well, that is the reason we have the bullet here. Obviously there were a number of problems associated with that -- why would we do that, would we want to get the transportation cask wet, would we want to wet the fuel and then have to redry it, what happens to a pool in a seismic event -- a lot of concerns are causing us, given the potentially smaller inventory needed, to consider dry storage instead.

Now for SRCR and SR we simply don't have time to put that in there. We will have the ability to show a waste storage facility but the expectation for license application is that dry storage may make a lot more sense for the reasons we just talked about.

See the numbers here in reduction of cranes and drop heights. I certainly at this point wouldn't want to commit that four is the final number of cranes but the whole concept in this facility reassessment was to try and develop a simpler approach to fuel handling and we are using as models a lot of what the Navy is doing up in Idaho. They don't lift their canisters very often. Generally they left by using lifts, hydraulic lifts, underneath them, up-end the devices, close shutters underneath them, transport on skidpads, rollers. There's not a lot of lifts by crane involved. Consequently they have removed a lot of the drop accident scenarios so we are taking that sort of approach to try and define a set of requirements that says if you can get around having to do a crane lift, do so. If you can minimize the lift height, do so.

There are some conceptuals of a different approach to the surface facility that are trying to simplify it a lot. Another -- let's see, we obviously reduce the number of lifts there. We talked about the pools.

Shielding -- okay, when transportation casks come in, we have to remove the end-fittings, open the lids, that sort of stuff. Also for the packaging within the waste package itself, we'll have to be putting lids on there, doing backfills of inert gases, doing welding, doing NDEA on them.

Part of the concepts we are looking at is how can we do that with more protection to workers than previous designs, reduce exposures, facilitate potential reworks, so one of the concepts they are looking at is putting a set of shielding jackets around the waste package, around the disposal container. I mentioned earlier the trunnion thing. Part of that, one of the concepts there is that part of that trunnion arrangement is a shield and that that would be on the disposal container during its handling process through the facility.

Also, another is that on the closure weld arrangement you could do that in an area where shielded floor sections come down over the package and a shielded work station, if you will, comes down over the end of the waste package.

That leaves you a little annual gap for access to the individual welds but does in some manner facilitate being able to work closer to that device.

Another concept that the Navy at least has included in their large canister concept is inclusion of shield material within the canister itself. I wouldn't rule that out either.

Before I leave the design change part and go to the thermal uncertainties, any other questions on that?

MR. LEVENSON: One quick question.

MR. HARRINGTON: Yes?

MR. LEVENSON: What is the shielding internal to the Navy casks?

MR. HARRINGTON: I don't know. I don't know that I have asked them that. Certainly we have -- we can get that from them.

Because of the thermal uncertainties, we're having a lot of difficulty, both inside and outside the program, producing uncertainties.

And one of the big considerations is what can we do to reduce uncertainties. We're trying to address what are those things that contribute to it, and what is an appropriate set of actions to be taken to resolve those.

Obviously, there are physical and chemical changes, a function of time and temperature. We can reduce the temperatures. Some of those effects will be reduced.

The magnitude and duration of the coupled effects go up with increasing temperatures.

We've gotten a lot of input, and it's really obvious to us that the period of time of performance of a repository engineered solution is far longer than the history available to us for the engineered materials.

Certainly, some metals have hundreds of years or thousands of years worth of history, but because we're wanting the increased corrosion performance that we can get, we believe, from the latest corrosion-resistant, nickel-based materials, consequently there is really not a significant history to them.

So, as you know, we're doing a lot of age-accelerated testing in very aggressive environments up at Lawrence Livermore, but this is always an issue; that there's just not a lot of history associated with many of these materials that we're crediting.

Also, now, the extent of testing of the natural system that was induced by, say, the large block test, the single heater test, and even the drift scale test, is not the same extent that an overall repository would be subject to.

So all of these are thermally-driven uncertainties. We're having to then decide how we represent those in PA space, and what that means to us in terms of design to be able to come up with solutions that can adequately address those uncertainties.

This next graphic really is just a set of the various design features associated with the near-field processes. I won't go through all of the processes.

You can see them on your handout and I think they're things that you've heard about many times. But with respect to what that means to design, the current era has a preclosure period of 50 years. Okay, a moment ago I said 100 years.

The delta is trying to define what an adequate period would be that could allow us to remain sub-boiling, and still be something that we think is reasonably short? Now, Part 60 and Part 63 say that we have to have the ability to retrieve for at least 50 years from start of emplacement.

That sort of defines a 50-year period as the minimum preclosure. It also says that the Department has the ability to come back and ask for a different period, if we so choose. I don't expect we would ever do that.

So if we were looking to close in the minimum amount of period necessary, that would be 50 years, but given the design solution we have, that would be also be an above-boiling solution.

If we wanted to keep the host rock below boiling, that would be something longer than 50 years, and a little later in the presentation, there is a series of curves that are tradeoffs between ventilation durations, waste package spacing and aging of the fuel.

Thermal loading is 60 metric tons per acre. That's with these waste packages spaced a tenth of a meter apart, and it's really staggering. It's a repetitive pattern of 21 PWRs, Defense high-level waste packages, with DOE S&F canisters inside of them; 44 BWR packages.

There are a few 12-element PWR packages for the very hottest PWR fuels, but it's effectively a repeating pattern of a number of different packages, but the intent on having them close together is what we call the line-loading, and that's to have the cooler packages adjacent to the hotter packages, trying to act as heat sinks to allow removal of heat from the hotter packages and then reject it a little further down the drift.

DR. HORNBERGER: I think that I heard last week, 62 metric tons heavy metal. Did I mishear last week?

MR. HARRINGTON: Sixty-two per acre, you mean? I don't know where that came from. We've generally been using 60. Out of curiosity, where was that?

DR. HORNBERGER: That was the technical exchange last week.

MR. HARRINGTON: Okay, I'll find out where that came from.

DR. HORNBERGER: It may just be that I misheard.

MR. HARRINGTON: Okay. What this means to us is that if we did do the closure in 50 years, the boiling of water within the rock would peak at a few hundred years, 200-500 years. That front would extend about 12 meters into the rock.

It's really quite circular. We had asked the M&O to take a look at it, vertically, above and below, and horizontally, both sides, with the expectation that there may be some delta between vertical and horizontal, and it was really quite circular.

It would take 1-2,000 years for the drift wall to come back down below boiling, and at 10,000 years, drift wall would be back down at about 50 degrees C.

Yes?

MR. LEVENSON: I have a question. Everybody keeps using the word, boiling. Here I see that you've put it in quotation marks.

What is the significance of boiling? There's no discontinuity of the vapor pressure curve at boiling. What's the significance of boiling?

MR. HARRINGTON: A sensitivity to mixed-phased flow. There is a concern that if we have the rock above the boiling temperature of water, then it will be very difficult to model what happens to moisture coming in, and then the vapor phase of that water as it goes somewhere, either out or back in.

MR. LEVENSON: So this isn't a safety issue at all; it's your inability to model it. If you adjust your design, would it be easier to model?

MR. HARRINGTON: Obviously, there is a perception that if we can't model, then we don't know what would happen to the waste package, and that it would translate to a safety issue.

MR. LEVENSON: That's true of a lot of things in this world we know about, that we can't model. But I don't understand the significance.

This is not going to heat up instantly.

MR. HARRINGTON: That's right.

MR. LEVENSON: It heats up relatively slowly. And, in fact, a significant amount of the water, since there is no discontinuity in the vapor pressure curve, a fair part of the water in rock will be evaporated long before you ever reach the boiling point.

How do you take that into account? You're not going to have two-phase flow in a rock surface for a very long time, if ever.

DR. HORNBERGER: Sure you will; you'll just have it below boiling as well as above -- below 100 degrees as well as above.

MR. LEVENSON: Yes.

DR. HORNBERGER: If your problem is two-phase flow, then whether you're five degrees below or five degrees above boiling makes no difference.

MR. HARRINGTON: There is very strongly a perception that having it above boiling is a step function, in both performance and uncertainty, and I'm trying to relate concern --

MR. LEVENSON: But where does that come from? It doesn't come from vapor pressure.

MR. HARRINGTON: I really can't answer that. Possibly Dr. Brocoum or Mr. Bailey or someone might want to take a cut at that.

MR. BROCOUM: This is Steve Brocoum, DOE. As Paul said, there is a lot of concern, particularly by the Nuclear Waste Technical Review Board, that the uncertainties increase above boiling. We don't observe -- you know, we're now in the -- all the data collection we do is at ambient temperatures, so -- and we just have a few thermal tests.

So, their concern was that the uncertainties are lower and easier to understand and easier to model below boiling. I don't think there is a real concern, because a lot of people on the project believe that above boiling, in fact, improves performance, because it tends to drive the water more away.

So the real concern has been the degree of uncertainty in how we represent that and how we understand it as we develop our design.

MR. LEVENSON: Uncertainty in connection with what? It isn't uncertainty in connection with vapor pressure or rate of evaporation or any of those things.

MR. BROCOUM: I think that it's more connected to the information we collect, which is mostly at ambient, and being able to model and understand it, and then being able to extrapolate it to above-boiling design.

You would have to ask the people that raised these concerns. These are generally concerns, as I told you, that come from the Nuclear Waste Review Board.

CHAIRMAN GARRICK: Yes, but you're designing this thing, and it seems that what we're trying to do is figure out the design basis. And I think that's -- you know, if you're saying that you're doing it because people are asking questions, and you can't rationalize it from a first principles basis, you know, that's something maybe to be concerned about.

MR. LEVENSON: I would hope that you didn't modify the design on the basis of some of the questions we ask, some of which are based in ignorance.

MR. BROCOUM: One of the things we're doing is, we don't have to make that decision today. And I think that what Paul is trying to tell you is, we're trying to keep a flexible design so that as we get our arguments together and develop our models, and better understand the uncertainty and how it's related to all the parameters we're having, we can then make the best decision on how to operate the repository.

So that's the whole point of this presentation today, is to point out that we don't have to know that today, because this design that we have can both accommodate a below boiling by a few degrees, and an above boiling by a few degrees.

And if it ends up not being important, which way we go, then we can make that decision on cost, for example.

MR. HARRINGTON: We have a design basis for the design. We believe that we have adequate modeling to show what will happen during above- and below-boiling scenarios.

The part I was struggling with was explaining the rationale of other organizations. So, I'm comfortable with ours.

MR. HARRINGTON: Contributions to corrosion of the waste package. Obviously we need to know near field host rock issues, temperatures above boiling temperature of water at that elevation, low relative humidities, what that does in terms of precipitants and salts. Obviously accumulation of that can affect the ingress of water into the drift, therefore onto the package potentially.

The drip shield and the waste package surfaces themselves be above boiling, lower relative humidity, what has been deposited on them by water coming in from the host rock and how does that then drive corrosion of the waste package, and the invert itself.

One of the things we're looking at in the invert and the host rock below invert proper is fracture flow out of the drift -- will the flow paths remain to remove water similar as to what brought water in, or may there be something going on that would cause them to plug and increase water concentration in the drift.

Question?

CHAIRMAN GARRICK: Yes. Do you have any specific information about what sort of salts you expect to be more concentrated than 10 molal?

MR. HARRINGTON: I don't. I'm sorry.

Okay. Several different types of corrosion mechanisms on the right-hand side of the page, general and localized corrosion, we will have that. There's nothing we can do to get away from that. It's relatively low dependent, not very dependent upon temperatures. Given the aqueous conditions, we expect that.

Pitting and crevice corrosion, though, we don't expect to see that based on the lab testing that we've been doing. We are continuing that. Stress corrosion cracking, though, based upon what we've done at Livermore, we have seen some of that. Consequently, then, the redesign of the closure lids on the end of the waste package.

Somewhat temperature dependent, near boiling. Less so otherwise. And phase segregation fairly low for temperatures below about 260 degrees C, which, as I said, the waste package skin will be generally lower than that.

CHAIRMAN GARRICK: What does phase segregation mean?

MR. HARRINGTON: The question is, what does phase segregation mean, and I'm not a metallurgist, I have only a vague understanding of the mechanics of the metal phases within the heat affected zone and they change. I think there is some migration.

CHAIRMAN GARRICK: That's what I understand it to mean.

MR. HARRINGTON: Okay.

Degradation of the waste form itself, okay, the degree of cladding degradation is formerly dependent. We recognize and understand that, but that's primarily an effect above about 350 C.

To date, we have held simply a straight 350-C temperature requirement on cladding. We've gotten input and recognize ourselves that it would be more accurate to have a time-temperature dependence, but that's additional work, that if we don't exceed 350 at this point may not offer us commensurate benefits with the resources. So, yes, we'll understand the issue there, but as long as we're keeping the cladding below 350 C, we think that's conservative.

Solubility of the waste form, somewhat temperature dependent. Degradation rates of uranium oxide vary by about one order of magnitude between 25 and 96 C. We don't have test data above those temperatures yet but think that we're being conservative in our modeling of that at this point.

Okay. These are -- the next page --

MR. LEVENSON: Excuse me. Is that in salt water like what's in the bottom here, or is that in pure water?

MR. HARRINGTON: I understood that to be in concentrated J-13 water. That's generally what we're using as the testing medium for these in situ tests.

MR. LEVENSON: What's J-13 water?

MR. HARRINGTON: Oh, I'm sorry. J-13 is one of the water wells at the site. We took water from that, analyzed it for much of the testing that's going on at Lawrence Livermore, we have concentrated that. We duplicate the water in a concentrated fashion.

MR. LEVENSON: Okay. The context of my question is, from the previous slide, one of the things that could cause pooling is if you get salt accumulation which plugs things up and --

MR. HARRINGTON: Right.

MR. LEVENSON: -- fill things back up. So I guess the question is, what's the rationale? If you're going to have water there, isn't it going to be whatever came from the previous slide?

MR. HARRINGTON: Yes. Yes, that's the J-13 water.

MR. LEVENSON: But that's not -- no, no, no, no.

MR. HARRINGTON: Wait. Okay. Let me go back.

MR. LEVENSON: No. The previous slide, the invert accumulation and fractures, precipitants and salts could result in pooling of water.

MR. HARRINGTON: Yes.

MR. LEVENSON: That's the water that's going to be in contact with the fuel, right? So why --

MR. HARRINGTON: Yes.

MR. LEVENSON: -- do you use a different water for the test?

MR. HARRINGTON: Well, the J-13 water is representative of the water at the site and the concentration --

MR. LEVENSON: Not what's representative of what would accumulate in the repository.

DR. HORNBERGER: Right, but I don't think that we would expect that the local pooling in the invert would flood the waste element. The waste elements would still be exposed to water dripping in through the rock, and it might be concentrated due to the thermal effects, evapo concentrated, but it certainly wouldn't be the same as water that you would anticipate pooling in the invert.

MR. LEVENSON: I disagree because what drips in from the top is not going to see the fuel. Fuel is only going to see what pools up from the bottom and reaches it.

DR. HORNBERGER: If that's the case, I think we all doubt that the fuel would see any water.

MR. LEVENSON: Well, I agree.

MR. HARRINGTON: Yes. The actual expectations are for water on the fuel is that dripping would eventually degrade the top of the package, fill the package up rather than filling the entire drift.

These are a series of tests and analyses to address thermaling induced uncertainties. They are categories, hydrologic, mechanical, chemical, et cetera. Within the hydrologic, for example, the volume and the fate, what happens to the mobilized water, is one uncertainty, so we have a series of tests going on or that have gone on or are planned to address that, including the drift scale test and the single heater element test, which are complete. Our large block test and the single heater test are complete. Drift scale test is ongoing now. A cross-drift thermal test is something that we're planning for the future.

We drove the somewhat smaller cross-drift across the repository horizon, somewhat above the plain of the emplacement drifts in the repository horizon down at about a 45-degree angle simply to get a more representative understanding of the rock across the plain. And because in part the existing drift scale test is in a rock that's representative of a relatively small portion of the repository horizon itself, we expect to do another drift scale -- or heater test over at the end of the cross-drift just to be in the actual lower lift where about 85 percent of the repository resin is located.

Mechanical fracturing of the rock above, there is a concern, especially with elevated temperatures, that you may get degradation of the rock itself if you subject it to significantly elevated temperatures and what then would be the effect on drift stability post-closure.

Chemical processes going on there. We've talked about that a little bit. Corrosion, we've talked about that a little bit. And waste form degradation. Again talked about that a little bit on the previous slide.

DR. HORNBERGER: Paul, just a quick question. I notice under corrosion, you have iron meteorite analogs.

Are there natural minerals that -- nickel alloys that are close to Alloy-22?

MR. HARRINGTON: I think that what I've heard is the use of those meteorites, since they contain some nickel, as being maybe the closest analogs to that. I have not heard of anything more representative. It doesn't mean that somebody hasn't determined that there is.

Let me jump to page 12 -- 11 was very similar to 10 -- and I see I'm getting a little close on time. We're creating a strategy for addressing the uncertainties. The next several pages capture that.

That has been presented by Abe Van Luik to the Board. We're treating the uncertainties in the SRCR and then developing guidance for how to do that in the LA.

This is being led in part by Bill Boyle and a team and participating on that are Abe Van Luik and the PA folks. You folks may or may not have had some interaction with that yet. But it's basically got four key parts to it: analyzing the known uncertainties, assessing all of the uncertainties, managing the uncertainties, and communicating them.

So in a little more detail, the analysis is to identify what the uncertainties with respect to the mathematical models are, variability and parameters, what are the potentially disruptive events, sensitivity and importance analyses, determine which features are truly sensitive to performance and which are not. That sort of activity is really kind of fundamental to repository safety strategy which Jack Bailey will talk to a little later. It's identifying what are the significant contributors to uncertainty and where should we put our resources.

Okay. Assessing all the uncertainties, how do we treat that in TSPA, the limits that we're assigning to the distributions of those uncertainties, confidence in the models and importance of those with respect to conclusions that we're drawing, and what uncertainties do we know about but have not incorporated, and how might we treat unknown unknowns.

We think we're identifying design basis events. What happens if there's something that comes up that we have not yet identified? Stress corrosion cracking is a good example. Until relatively recently, we had not thought that was going to be an issue. It turned out to be, so we came up with a design.

So what sort of defense-in-depth features do we need to have to allow us to have a design that can accommodate uncertainties in the future?

We need to manage those uncertainties, identify which are the important ones, and how might we reduce or mitigate them.

There are a number of different contributors there: What measures do we need to have to increase confidence?

What flexibilities, we talked about that a moment ago, potentially changing the design to address those, and then communicate those.

I want to go the operational flexibility discussion.

CHAIRMAN GARRICK: Just in passing, the whole issue of uncertainty deserves a special session all of its own, and I don't want to get into it too much.

But the Committee is, of course, very interested in this, given the emphasis that exists with respect to a risk-informed approach. And I think eventually we're very interested in knowing just exactly how you're handling unknowns of unknowns, for example, and whether or not you are building into your distribution functions, allowance for what some people might call unquantifiable uncertainties.

MR. HARRINGTON: Okay.

CHAIRMAN GARRICK: I don't particularly like that term myself, but that's a term that's being used in the reactor arena.

So, I think that the state of the art is in pretty good shape as far as information uncertainty is concerned, but once you get into modeling uncertainty, it's an entirely new ball game.

I think there are those who believe that this is the major contributor to uncertainty, and given that, it has to be something that we put quite a bit of attention on. So I think that sooner or later, we're going to really want to home in on those contributors to uncertainty about which there's not really a good mathematical trail.

Sooner or later we'll want to come back to that.

MR. HARRINGTON: We'd be happy to do that and make sure we get the right people here to do that for you.

CHAIRMAN GARRICK: Right.

MR. HARRINGTON: Okay. A lot of discussion had taken place a year or two years ago, even relatively recently about an above-boiling versus below-boiling design. And they were almost considered to be either/or; either you had one or you had the other.

One of the considerations criteria for selection and the LA design selection activity a year ago was flexibility for change, as I mentioned earlier. We chose EDA-2, Enhanced Design Alternative 2, in part because it has quite a bit of flexibility.

Given the interest and potentially keeping the host rock below the boiling temperature of water and the post-closure arena, we've come to realize that EDA-2, by turning a few knobs, can also be made to do that.

So this next discussion really is on which knobs are the right knobs to turn? Why did we come to that conclusion, the conclusion of which knobs are appropriate, and what does that mean to us in terms of tradeoffs between ventilation duration, waste package spacing, and aging of fuel?

And there are obviously a few other things that could be considered also. So, what will be in the SRCR design and considerations in establishing that, controlling thermal responses, this is the intro to the rest of it.

There may be a number of reasons to have a flexible design. Obviously, policy, should we develop alternative technical objectives, get new information like a somewhat hotter waste stream, for example or other considerations.

There were a few design requirements and features that we have, really not a lot. The cladding, we want to protect that, so we'll keep below 350 C. Now, certainly if that were sort of the defining feature, we'd probably want to invest more time in developing the time/temperature curves above that.

But especially in consideration of host rock temperatures, cladding at 350 is reasonable as an item to keep. We also wanted to allow water to drain between drifts.

That was one of the fundamental precepts of EDA-2, where we move from the VA spacing of 28 meters to the last spacing of 81 meters between drifts. That really was to dissociate the thermal effects from one drift to another to provide a cool regime between drifts so that you wouldn't develop a potentially pond of water above drifts if you were above boiling.

Even if you had localized boiling, there is still a reasonable flow path between drifts. The DOE simply said provide a flow path; the M&O has assigned a number of 50 percent of the pillar ligament width to be the number.

Design features, 81 meters; the 7.6 kilowatt average waste package power, I mentioned earlier, 11.3. The 11.3 is for the 21 PWRs, taking all waste packages together, the Defense high-level waste co-disposal, the BWR, the Navy fuel, et cetera, average is 7.6.

At a tenth of a meter spacing between them, that then comes out to just under 1.5 kilowatts per meter, average power density.

We've got a ventilation flow rate of 15 cubic meters per second. That's up appreciably from the VA. We think that's effectively about as fast as you can pump air through there and still remove additional heat.

We've looked at going above that, but the amount of heat actually removed above that flow rate was minimal.

It wasn't worth the tradeoff in additional capital expenditures for that.

In terms of what that means relative to miles per hour of wind down the tunnel, that's about a mile an hour, given a 5.5 meter cross section.

MR. WYMER: That's the flow rate per drift?

MR. HARRINGTON: That's per drift. Now, remember that a drift has inlets on each end, and an exhaust down through the middle.

So when you look at the number of drifts, you have to consider each end of each drift when you add up to get the total flow rate.

Also, drip shield on the packages, the fuel is an average of 26 years old at point of receipt at a repository.

Now, operational features, as distinct from design features are the spacing between waste packages.

The preclosure period, how long might you keep the repository open, and the amount of staging or aging of fuel prior to emplacement, and the last drift loaded, takes about 25 years to do emplacement.

There are about 70,000 MTU at about 3,000 MTU per year, so it's about 25 years, so that means that the last drift emplaced would only have about a 25-year cooling period prior to closure, if you did a 50-year closure of the entire -- 50-year entire preclosure period.

So that means that, again, the host rock would get up to about 200 degrees C, and that the front would eventually advance in about 12 meters.

A number of considerations, starting in the top left with the fuel itself, okay, the enrichment of the fuel as a contributor, the exposure -- that's the time in core, leading to burnup as a contributor, the age from point of discharge from the reactor is a contributor. The longer the point of discharge, aging, the cooler it is.

Those factors then determine the thermal output of the individual fuel assemblies, and that along with the number of assemblies in a waste package, the mix of assemblies in a waste package, sets the hotter and colder assemblies -- potentially, we might even mix boiling water reactor fuel elements along with PWR elements in a single package.

That introduces some additional design and operational complexities, though, so we wouldn't do that it unless it really provided a benefit.

MR. WYMER: How much analysis have you done on what you might call the tradeoff between the controlling the temperature in the drift by providing a lot more surface storage capacity for long decay times before you put it into the drift?

It seems to me that that's a tradeoff that you could consider if you're talking about years.

MR. HARRINGTON: Right. And that shows up in a couple of slides on a set of curves. There is a set of curves for staging that is the aging of the fuel, either on the surface at a repository or if we're successful with utilities, there.

MR. WYMER: So that's coming up later?

MR. HARRINGTON: Yes.

MR. WYMER: Okay.

CHAIRMAN GARRICK: In this issue of operational flexibility, one of our former members reminded us that there is not only the opportunity here to engineer the near-field, and, most particularly, the waste package, but there is also a great opportunity to engineer the natural setting.

Now, except for the spacing of the tunnels, you haven't said much about things that are under consideration or that you might do to the natural setting to enhance the flexibility of the repository, or, more particularly, to reduce the likelihood of water having access to the near-field.

Is this something you're also doing? I'm thinking here of everything from a drainage system, to diversion systems, to Richard's barriers, to what have you.

MR. HARRINGTON: Well, we've talked a lot in the past about what modifications we might do to the natural system around the drifts. I know one concept had several, two or three emplacement drifts stacked vertically with a cap over it to try and shed water.

What that did for us, though, was concentrate the heat, and, effectively, you were reducing the overall emplacement area, you were having drifts closer together than they would otherwise have been.

So we were not then able to take advantage of being able to reject heat into the further-field. That was causing some problems.

Another consideration with that was what happens to the water once it passes the lips of those shields? There is a fair amount of fracturing, and there is some lateral movement of water also as it goes down.

So, yes, we've looked at number of different natural system modifications. To date, we have not determined that we would proceed with many of those, simply because of the concern over how well they can work, how well we can demonstrate them to work in a regulatory arena, and the cost/benefit tradeoff of them versus some of the other things we're doing.

CHAIRMAN GARRICK: I guess what I'm thinking of is that the regulations are pretty explicit with respect to the performance being dependent on both engineered systems and the natural setting.

MR. HARRINGTON: Right.

CHAIRMAN GARRICK: And it seems that we're moving, we're getting a much better handle on what the contribution to performance might be from the engineered systems than we are from the natural setting. I realize that the whole site characterization program was designed to provide the baseline information on the containment capability of the natural setting, but somewhere along the line, that question is probably going to have to be addressed in a quantitative form or some sort of a quantitative form as to how much of the performance really comes from the natural setting.

I'm just curious as to -- without taking a lot of time here to discuss that, if there is some sort of an effort comparable to what you're doing here, to quantify the impact of the natural setting on bottom-line performance.

MR. HARRINGTON: We are spending a great of time trying to understand what the natural system is and what its effect on engineered features would be, and, therefore, the contribution of the natural system to the total system performance. Modifications that we might do to the natural system, I guess I would really have considered those to be engineered features, something like a shield of clay or whatever it might be, above emplacement drifts, is really an engineered feature. Trying to make this --

CHAIRMAN GARRICK: But you try to engineer it in such a way that you take advantage of the natural properties.

MR. HARRINGTON: This is true.

CHAIRMAN GARRICK: And that connection has got to be very important. We all know, too, that the state is extremely interested in having insight on the capability of the site to do this job as much as it possibly can on its own, without undue assistance from the near-field engineered systems.

And, of course, in Europe it seems that the emphasis is much more on the natural setting than it is on the near-field and the elaborate designs of the waste package.

MR. HARRINGTON: Yeah. I had the opportunity to go to Sweden last fall and went to the hard rock lab, to the canister development lab, and to their interim storage facility, and that was very enlightening.

CHAIRMAN GARRICK: Right. Okay.

MR. HARRINGTON: They have a little different set of issues to deal with. Because of the interim storage facility, they inherit, at a repository, appreciably cooler material than we are having to accommodate in a design, and they also have only about a tenth of it. So, both of those would be beneficial tradeoffs.

DR. WYMER: But you don't really have to accommodate higher temperatures if you have substantial surface storage for an extended period of time.

MR. HARRINGTON: That's true.

DR. WYMER: It seems to me that is a tradeoff that a fair amount of attention ought to be paid to. You are actually talking about going down in your amount of inventory you need. It seems to me, you might be thinking about going up.

MR. HARRINGTON: Well, if we go to staging, some appreciable staging, yes, that number would go up by --

DR. WYMER: And the total problems go down.

MR. HARRINGTON: Yeah. Yeah. Well, the thermal content, the temperatures would go down. Whether or not is a problem, you know, if we can make a case that says an above-boiling repository is adequately understandable, defensible, uncertainties are acceptably low, then that may be a reasonable path to take if we show commensurate cost benefits.

Now, as we get a little further back to that chart I mentioned earlier, there are a number of five different cost points on it. Every one of them is $6-$8 billion more expensive than the closure at 50 years with letting the post-rock go somewhat above boiling. So, again, it is a tradeoff. So, if we can make an adequate technical case that says it is reasonable to close and go above boiling, then that is a substantial amount of money that doesn't need to be spent.

MR. LEVENSON: I want to ask a question. In your present concept, at the time you get ready to close the repository, when would the last fuel that is scheduled for the repository have come out of a reactor? What is the minimum cooling time?

MR. HARRINGTON: Five years. The minimum cooling time is five years. In the standard contract, there is a requirement that all fuel be at least five years out of reactor. With respect to defining a waste stream other than that, at this point we don't have that. That is something that we would like to get to.

We talked about that a little bit earlier, our need to develop what the best emplacement scenario would be. I am not convinced that I want to take all the cold stuff first and delay the very hottest till the end. It may make sense to retain some of the colder stuff toward the end to offset some of the hotter stuff that will be generated then, but we haven't finished that work yet.

MR. LEVENSON: Okay. That was the exactly the context of my question, is that, if, in fact, putting hot fuel in the repository causes problems, you ought to put the hot stuff in while you have the longest period of forced ventilation and cooling, put the coolest stuff in just before you are ready to close it up.

MR. HARRINGTON: Yeah, that is an approach, and, obviously, that is one of the things we are considering.

Let's see, that is thermal output of assemblies along with -- another question? Okay. Along with those things contribute to the thermal loading, distance between drifts, ventilation duration and rate give the overall thermal response.

Why did we choose the things that we did to use as operational variables? Enrichment, we can't control that. Exposure, time spent by assembly in core, we can't control that. Age from discharge, we can address that through the use of staging, either at point of receipt or prior to emplacement. Number of assemblies in the waste package, obviously, that is something we can change, but changing the spacing between waste packages has the same effect, so we settled on the latter, it is a little more manageable. It also would not necessarily increase the number of waste packages.

Let's see, blending of dissimilar assemblies, we talked about that a little bit in terms of the BWR and PWR. For perspective of this exercise, though, we have already got blending covered as an operational mode with the hotter and cooling waste packages, and, so, we think that is manageable. Distance between waste packages, obviously, we can control that.

Distance between drifts, now that we decided to move them out as far as they are to 81 meter spacing, that is center line spacing, there is relatively little effect on thermal interaction from one drift to the next by trying to keep this large sub-boiling region between them to facilitate the drainage. So, that is not a significant contributor.

Ventilation duration, we can control. Ventilation flow rate, right now we are expecting that the 15 cubic meters per second would remove about 70 percent of the heat generated by the waste after placed underground prior to closure. There may be some ways we can change the layout of that, but, operationally, it might not get greater than maybe 80 or 85 percent efficient. But we think that we have got that effect bounded by the consideration of staging, that is 100 percent heat removal. So, from an operational perspective, we think staging covers it.

Yes?

DR. WYMER: At closure, do you intend to plug up all these ventilation ports?

MR. HARRINGTON: Yes. Yes.

DR. WYMER: In general, close the whole darn thing?

MR. HARRINGTON: Yeah. We talk about the backfill in the emplacement drifts and we said that we have made a decision that that would not be part of the case, as Steve correctly pointed out. We didn't rule it from future consideration, but that is just the emplacement drift for the thermal issue. The parameter drift, the ventilation drifts, the access ramps, those, we would expect to backfill and put seals in.

DR. WYMER: It would be sealed?

MR. HARRINGTON: Yeah. We have looked at what is the feasibility of operating this design to keep the rock below boiling. Those three things that we have talked about, the staging, it is aging of waste packages, increasing the spacing between the waste packages and increasing the duration of the ventilation, there is a link to preclosure duration there certainly, are things that we can, from an operational perspective adjust to keep the host rock below boiling if we determine that that, in fact, is a necessary or valuable feature.

There are some hot spots, some areas in the host rock that would be above boiling even if we did that. Typically, that is in the invert blow the waste package where the support component for the waste package is touching the waste package and then able to conduct to the invert, and in some areas of the host rock immediately adjacent to the hottest packages, but that is a very limited effect.

We have, we think, general consensus that that very limited amount of rock above boiling is not problematic. The concern by many is really a more extensive degree of above-boiling.

That brings us to the curves. This has been referred to as the Rosetta Stone, a number of other things. Let me walk through it in a set of issues. Okay. First, we will talk about the years of staging. This is the amount of life of aging that would be given to fuel assemblies prior to emplacement beyond the average age of fuel at receipt now, which is 26 years. So, basically, if we received it in the front door and emplaced it relatively soon, that is considered to be no staging, if we had the ability to let a fuel assembly cool for an additional 10 years, either at repository or utility, it doesn't matter, then we could be out on these curves.

What this is is the set of distances between waste packages, this is the gap, not a center line spacing, versus ventilation duration after loading of a waste package, that you would then either be below boiling in the host rock after closure, or above boiling in the host rock after closure. Preclosure period, it stays below boiling all the time because of the higher ventilation flow rates that we have now. The issue is postclosure. So, above and to the right of each of these curves, host rock stays below. Below and to the left of each of these curves, host rock would go above boiling to some extent.

Now, we have got SR base operations here. That is because SR has a tenth of a meter spacing between packages, and for a 50 year closure, with about a 25 year emplacement period, then that leaves about a 25 year ventilation period. So, that is where that falls, but that is also relative to years of staging zero, so, it is substantially on the above-boiling side.

One point to consider is if we had no staging and we wanted to keep the minimum distance, we could, between waste packages, minimize the extent of tunneling and drip shields, but yet close at 100 years. What is the point? Okay, this is the point, there is no staging and it intersects this 100 year preclosure line. What this line represents, each point on this line is a sum of three things. It is the sum of the staging, plus a 25 year emplacement campaign, plus a ventilation duration after completion of emplacement.

So, for example, here, no staging, 25 years about of emplacement, plus an additional 75 years of ventilation after that means closure in 100 years. In January, when we agreed with the M&O that the removal of backfill was the most appropriate solution to the increased thermal content issue, we sent the letter -- a letter to the M&O and directed them to develop a change request to remove the backfill from the current design, not to preclude it, but to also answer a number of other questions. And one of the caveats we put in that was to come up with a design solution that could allow closure in about 100 years. That seemed to be a reasonable approach for trying to keep a sub-boiling repository.

MR. HARRINGTON: Each of these points on the curve, then, represent what a 100-year preclosure duration would look like. So if we ended up with, say, ten years of staging and had a spacing between the packages of about 1.4 meters and had about a 65-year preclosure duration of ventilation after completion of emplacement, we could close in 100 years and remain -- keep the host rock below boiling. So that is then these sets of curves and what this one represents.

Now, we put some limits on this thing. One of them, you see nothing goes beyond 75 years. We could have, but the reason for that was we said we wanted to see 100-year preclosure, so this represents 75 years in ventilation plus 25 years of emplacement.

There is also an upper bound to it, and we'll get to that in a slide or two where I had shown you the layout of the repository subsurface with the lower and upper blocks.

To accommodate 97.4 MTU -- it's really MTHM -- what that represents is 84,000 MTU of commercial fuel and all of the DOE high-level waste and SNF. That's considered to be equivalent to about 13,000 MTHM. That's what we're using for our total system life cycle work, so that's something that we wanted to be able to address.

Given the finite amount of space in the upper and lower blocks, we wanted to see how much we could use and still fit within that. Now, you may remember that in the EIS, we show for the low thermal load, the 25 MTU, 105 -- 25 MTU per acre low thermal load -- the 105,000 MTU commercial fuel case.

Obviously that is more than in the upper and lower block, so we have some satellite regions out below Jet Ridge across the canyon for that. But with respect to really the primary area of focus, the upper block and the lower block on the east side of Ghost Dance, there's a fixed amount of space. So to fit the TSLCC quantity, the total system quantity into that space, we can't have more than about four meters between packages. So that's the upper limit.

Now, we wanted to do some trade-offs, okay? We have the costs associated with that point on the curve, but we wanted to see what it would take for several other scenarios, so we looked at this cost and doesn't involve any more staging, but it's about 2.3 meters between package, so there's more tunnelling involved.

The drip shield segments are not individual drip shields over individual waste packages; they are continual segments. Therefore, if we increase the space between waste packages, that then increases the amount of drip shields required even though it doesn't increase the number of waste packages.

So because of the increase in spacing, tunneling, drip shields, and also because it would require 75 years of ventilation after emplacement rather than shutting it off at 50 years, there's about $6 billion additional total system life cycle costs and net present value that's discounted to about six-tenths of a billion.

One of the reasons for that is the procurement of the additional drip shield material doesn't happen until the end, until closure, so you would be setting that out 75 years.

Okay. Also on that zero year of staging, we went out to the maximum spacing that would still fit within a characterized area -- four meters -- that's about seven billion, about nine-tenths of a billion net present value. It's a little more expensive than this, driven by the tunnelling and drip shield costs more than offsetting the reduced operations and maintenance cost of having the extended ventilation.

Okay. It went down to the ten-year staging line and took several spots on it. One again is the 75-year ventilation period, and that's about six-tenths of a billion. We came back to the same 2.3 meter spacing as we looked at here. It's about seven-tenths of a billion. And came back to the same 4 meter spacing as we looked at here, and that's about 8 billion.

The progression here is the same -- six to seven to eight. We see that it's costing us more money to go with the greater spacing, the additional amount of tunnelling, the additional amount of drip shields than we're saving due to reducing the O&M costs on the ventilation period.

CHAIRMAN GARRICK: Paul, I hate to do this to you, but can you wrap it up in about five minutes?

MR. HARRINGTON: Yes.

CHAIRMAN GARRICK: We have a comment from the public that we want to accommodate.

MR. HARRINGTON: Okay. There's just a couple more slides after this.

CHAIRMAN GARRICK: Okay.

MR. HARRINGTON: The next one is the layout we looked at earlier. The reason I put this in here was to point out where these items fell with the 70,000 inventory at a tenth of a meter. It goes here.

The whole TSLCC at a tenth of a meter goes to here. 70,000 at 2.3 meters goes here. The EIS inventory, the 119,000, that's the extended case for EIS at a tenth takes this much. We can even accommodate the EIS at 2.3 within this, but trying to go beyond goes out further.

This is a graphic representation of the tradeoffs between space and amount of the upper and lower blocks that's required, and really the last are summary slides. We think it's flexible, we think it's the right thing to do, and that's the main discussion. The rest of it really is summary of what I've already said, so I won't do that in the interest of time.

Questions.

CHAIRMAN GARRICK: I'm just curious. This whole project and its immensity would lend itself well to very interesting simulation, particularly with respect to the operations and the exercising of these parametric curves and what have you. Are you doing some of that? Are you doing computer simulation of the operations?

MR. HARRINGTON: Yes. There's something called a witness model that the M&O is using. I'm not sure how widespread it is. I understand it's fairly widely used. And they are using mean time to repair values, mean time between failure values that they're pulling in from industry from previous experience, and plugging into the witness model is primarily an exercise that the surface facility folks are going through to identify where the hold-ups might be.

We have, obviously, more work to do there. Some of the initial values that they were using were very optimistic with respect to, say, times to repair major crane failures, things like that.

So yes, we're doing a lot of computer modelling of handling activities, those sorts of things.

CHAIRMAN GARRICK: Using the VA as a baseline for a moment, and you've presented some of that information and you have the curves that probably answer the question, but what price are you paying or savings are you attaining as a result of going from, say, the VA design to the so-called flexible design?

Obviously you've saved about a billion dollars, have you not, by eliminating the backfill.

MR. HARRINGTON: Going overall from VA to LADs was more expensive by about $4 billion. Giving up the backfill, the number associated directly with that, last I remember, was about $600 million, so say on the order of a billion dollars.

CHAIRMAN GARRICK: So the $4 billion is what the -- the delta increase?

MR. HARRINGTON: Was, yes.

CHAIRMAN GARRICK: Yes. Was.

MR. HARRINGTON: Yes.

CHAIRMAN GARRICK: Okay.

Go ahead.

MR. BAILEY: I would only restate what I said earlier. It seems to me that there is some advantages in putting in more surface storage space not only with respect to the thermal problem, but with respect to giving you a chance to evaluate some of your design as you go along and make changes over time in the package design or whatever.

MR. HARRINGTON: Yes.

MR. BAILEY: So I suppose you've done these trade-offs, but it seems to me that that is very much worthwhile.

CHAIRMAN GARRICK: Yes. I would extend that question to include the total system, because with the direction that plants are going with dry storage and extensive risk assessment of the dry storage facilities, it seems as though something that would be very interesting, and I don't see that you have that, would be a comprehensive plan for the management of the -- of a variable is critical as fuel aging.

MR. HARRINGTON: Okay. The surface study that I was referring to earlier that you won't see in the SR but what we'll be using as a basis for the LA work is identifying how the surface facility would accommodate that, and right now, what they're looking at is to have the flexibility for three major sets of target approaches to developing inventory.

One is to -- if you had some particularly hot fuel that you really did not want to take underground but you were ready to load into a waste package, load it into a waste package and set that on the surface and some structure and allow it to age there rather than inputting all of that heat underground.

Another is that you may want to have some sort of canistered storage facility rather than the waste package either if we're receiving non-disposable canisters, store them that way, or develop our own non-disposable canisters if that was the right design solution. So we're looking at those two.

CHAIRMAN GARRICK: Isn't that kind of going back to the original concept of multiple-purpose containers or canisters?

MR. HARRINGTON: Well, the multi-purpose canisters were intended to be disposable also in addition to storable and transportable. We've never really given that up. Yes, the department quit developing it, but from a disposal perspective, obviously that would simplify our surface facility immensely if we didn't have to handle individual fuel assemblies.

The Navy canisters are in effect MPCs.

CHAIRMAN GARRICK: Yes.

MR. HARRINGTON: They are large disposable canisters that we would never have to open. But the other side of that is, then, that any understanding of fuel necessary for disposal would have to be accomplished at point of canisterization.

Right now, the standard contract doesn't require utilities to identify a great deal of information. If we need to do some more characterization or do some observation prior to canistering, that will have to be done at point of loading.

The third thing between either loaded waste packages or canisters is also DOE waste. Because of the need to sort of intermingle the hotter and cooler packages, it makes sense to us to have some DOE both S&F and high level waste canisters available for that, so this study is looking at adjacent pads to be able to store that sort of material.

CHAIRMAN GARRICK: Okay. Well, thank you very much.

We do have Amy Shollenberger who wants to make a comment, then maybe we should do that right now, and then the committee has a picture appointment at 10:30, which we have just passed, but as soon as we break up, would you stay together so we can accommodate that.

I guess, Paul, we're finished with your presentation. We appreciate it. It helps us a great deal.

MR. HARRINGTON: All right. Thank you.

CHAIRMAN GARRICK: Amy.

MS. SCHOLLENBERGER: I'm here representing Public Citizen's Critical Mass Energy and Environment Program. Thanks to Chairman Garrick for making a few minutes for allowing me to comment.

I have a few questions that I don't really expect answers to right now, but I just wanted to get them on the record:

The first is, this discussion about interim storage happening onsite at the reactors to allow for aging, I'm curious to know how, if there's an agreement worked out with the reactors for that onsite storage, how will that affect especially the transportation schedule and the queue, and also eventually the placement schedule?

Will that push it out past the 25 years, because it may take longer to get everything to the repository if stuff is aging onsite. If anybody has an idea where I might get that answer, I'd appreciate it.

Secondly, I'm wondering, with this idea about flexible design, it seems to me like what DOE is really saying here is that this design is never actually going to be finalized until the repository is closed, if that ever, indeed happens.

And I'm wondering how in the world they're going to complete an FEIS and show what the effects on the local environment and the local public health is going to be if they have no idea until they're actually emplacing the waste, how it's going to be emplaced.

And as a follow on to that, I'm wondering, shouldn't there be another DEIS to allow the public to comment on all of these changes that are happening between the draft and the final EIS, because, you know, obviously what we commented on last year has nothing to do with what's actually going to happen at this point.

And, finally, this is not explicitly related to this presentation, but I think it is indirectly related. There has been a move throughout the NRC and also now it's in Congress with Senator Murkowski's new Energy Security Act, S. 2257, to take away the public's right to formal hearings.

And that move would specifically impact the Yucca Mountain licensing. And I'm really worried for the public that there's nowhere. If that happen, a move to informal hearings, there is nowhere where the public has recourse to any of these design changes, to even get the information until it's actually happening, and to comment on that information.

So, I would really once again -- Public Citizen has been saying this repeatedly for the past several months, but once again I would really like to say that it's really a mistake to take away the public's right to formal hearings.

It would be fine and maybe even desirable to do informal hearings along with the formal hearing, but it's absolutely not acceptable to not have formal hearings on this license.

And it's been pointed out by my colleague, Jim Riccio, several times that there was a promise made in the SECY paper that said that Yucca Mountain would have formal hearings, no matter what the NRC decided on the hearing process in general, and we would just really like to encourage you all to keep that promise.

Thanks.

CHAIRMAN GARRICK: Than you. Those questions vary from the very specific having to do with design, to the very global, having to do with Congress. And they are a part of the record, and I think they are deserving of a response.

I think we'll have to find a way to do that, other than through the session today, but we are pleased with your bringing them up, and somehow we will get to them.

Now, unless there are members of the Committee that would like to comment on anything that's been said, I'd like to maintain our schedule as close as we can, and, therefore, call for a break right now.

[Recess.]

CHAIRMAN GARRICK: We're going to now turn our attention to repository safety strategy, and George Hornberger will lead our discussion in this area.

DR. HORNBERGER: The repository safety strategy, as we understand it, is continuing to evolve. Jack Bailey is here to give us an update so that we can try to keep abreast of the progress that DOE and the contractors are making.

Jack, it's good to see you again.

MR. BAILEY: Thank you, sir. It's a pleasure to be here.

Yes, we're going to talk about the repository safety strategy. We're going to talk about the ongoing development of the repository safety strategy. As you pointed out, it is, in fact, continuing to evolve; it is not complete.

I will preface the entire discussions by, these are preliminary results. There are some results and some findings in here, and they are, in fact, preliminary, and we'll be back as we continue to move forward and work it.

We've had some confusion as to what is the repository safety strategy? It's a strategy, but it also is a plan.

I've got several slides here to try and get around what we're trying to accomplish with the RSS and how we're going about it.

It's central to the DOE's evaluation of the current technical knowledge and how to move forward. That's what the repository safety strategy is about. And we do that in a couple of ways:

First, there's a safety case, and you've heard the safety case before, and it will show up a couple or three times in here. It's the five elements, the TSPA, margin, defense-in-depth, natural analogs, disruptive events, and performance confirmation.

And we think about how to hang the flesh on those bones, of here's how we want to make the argument. It's a layered argument. It's a mean by which we gain confidence that the system will work through all of these methods.

And the RSS takes a look at what we know about the current safety case, what we know about the current knowledge and how to move forward. So the plan is determined by management after you get technical input.

Now, management also gets to make some choices in this. It is not purely technical. You can decide where to put your resources. You have timing issues, you have money issues, you decide where it is that you want to go work.

Now, we chose the current, and we went to the license application. You can put VA, you can put EDA-2, you can put EDA-2 and SR, you can put SR and SRCR and SR, and you can think about it. We tried to do it in an iterative fashion as we get some new set of information.

I'm not sure everybody's slides in the audience came out as well as we had hoped. I think there was some double printing. If there was, let us know and we'll try to help you.

The iterative nature, you can jump in anywhere you want. Let's start up here with the repository system characteristics. That's the entire system, not just one piece of the system, but the entire system, because you have to look at the whole system here in terms of satisfying the standards, which happens down here.

And in there, you address your hazards for pre-closure, or your performance in the post-closure. You identify your credible features, events, and processes, define your scenarios, your event trees, get your probability, assess your consequences.

And evaluate results of your hazards analysis with the results of your performance analysis. Compare it with your standards, and then assess the uncertainties.

Decide what you know. Decide how well you know it, decide what confidence you have in order to move forward.

You assess then what do we need to do next? In one direction, you go and you say here's the safety case, we write it out, here are the requirements we're going to place on the system, and in some cases, the Q-list. We go all the way back to the basics of we have systems, structures, and components, and we're going to place requirements on them.

And so from there, you can do that. You also feed that back into the safety strategy. How do we hang the meat on the bones from what we know now? And then you decide what new information do I need to acquire?

How do I need to modify designs? What models do I really need? And so you're constantly going through these processes in an iterative fashion to come up with a design that is the design that you want to move forward with.

And I use design in the system sense here, not just in the engineering sense, but in the system sense. What do you choose to rely upon? What is providing you with the performance that you need?

What can you demonstrate about that performance through a rigorous licensing process? That always has to be in the back of your mind or in the front of your mind sometimes, because it becomes very important as to whether or not you can really prove what you're saying.

What are we trying to do in the RSS? Get an adequate understanding, the identification of the principal factors determining safety. We really try and look at the system and say what is it about this system that really drives the performance? What really makes a difference?

In a probabilistic sense, if we think we understand the system and we take a parameter and we push it all the way to the bad -- I'll call it -- edge of the distribution, and it doesn't change the result to the receptor at the biosphere, then we probably don't have to know a whole lot about that, other than have confidence that we have captured correctly, the basic behavior of that particular parameter.

If, on the other hand, we find something that really affects the far end, then we really need to have a good understanding of that.

We need to have an understanding of how it behaves and how either a good look at what the probability density function looks like, or something that we can clearly defend as a bound or a simplified area. I'll talk about that a little bit more.

We need to do the performance assessment. That is our tool for putting all of these pieces together for looking at the interaction, and it is not just the tool that

-- I want to speak highly of the PA, because it isn't just a tool that gives us a squiggly line or a bunch of squiggly lines at the end. It is the tool by which you assemble this, and then you start using your intellectual processes from your principal investigators, your PA analysts, and start deciding, does this system come together correctly?

Do these things make sense? Are they borne out by what we're seeing? Is the modeling really representative here?

And have we done simplified or bounding type approaches that, in fact, are skewing the answer or hiding something from us?

Those are the types of analysis we have to do. We learn from the PA. We not only get squiggly lines; we learn from the PA.

And then finally you have to have measures to increase your confidence in safety. Why are we sure? Why do we think we're right?

And there are measures to address residual uncertainty and any other potential vulnerabilities. And the word, vulnerabilities, is going to come up again later, and I'm not sure that's the right word. That's why this is preliminary, but we'll talk about some vulnerabilities.

I think you've seen this slide, but I really like it. There's an evolving technical basis, and it keeps going, and it runs off the edge of the page. It should be out here because it doesn't stop.

Performance confirmation doesn't stop. Study in the rest of the world doesn't stop. Inquisitiveness doesn't stop. It may not be quite the same height, but it's still there.

The viability assessment we put together, basically a viability assessment safety case that was found in Volume IV of the VA.

And it said here's what we know about the system, here is how important we think it may be, here's how much we know, and here's how much more we can know in a couple of years. That was the first look at where do we need to apply resources, because we can learn something in another few years, as opposed to 20 or 30 or 40.

For the enhanced design alternative, which if you recall was the corrosion resistant on the outside package, the drip shield, backfill, we did some preliminary analysis and came up with -- and we actually made some decisions as to where the performance seemed to be clustered, if I can use that word.

We did in this -- it's important to note that we did. In this, it's important to note we did a traceability. We did a transparency type approach where we followed a drop of water through the mountain. That's not how you did the

TSPA. We tried to find a way to get what are all the processes that it faces as it moves through the mountain?

And we gave all of them equal weight, and you'll see that in a minute. Here we went through there and we did exactly what I said, we started skewing those probability distributions to find out which ones really made a difference.

And the ones that didn't push the answer at the back end, we chose not to try and study as hard or in as much detail as we did the others, because the others make a bigger difference to the overall safety.

And what we're doing in Rev 3 -- Rev 3 was done off of VA models that were modified for a nominal run only, no probabilistic runs to speak of, off of the Enhanced Design Alternative 2. In Rev 4,, we will have run the TSPA for the SRCR, which I'll talk about in a minute.

We have a big improvement in the models that we can use to do our sensitivities, do our barrier analysis and do our study of the system.

Elements of the safety case. I ran through this one for you, you have seen it many times in the postclosure safety case. The repository safety strategy for Rev. 4 is going to include considerations of the preclosure. We have looked at the 10,000 year dose in accordance with the regulation. We are now going to start looking at the preclosure safety case. What happens in the local area because we are handling fuel, we are packaging fuel, we are moving fuel? And I talk about that, I will come back to it at the end.

And we go back and we do what is called an integrated safety analysis. That is a probabilistic approach to identify the operation of the system, what is important. We look at safety margin and defense-in-depth as a part of that. We do an analysis of design basis events. It still comes back to what are the events that typically bound the others, as opposed to a pure probabilistic. We look at industry precedent and experience. What has worked? What hasn't worked? How can we use it? And technical specifications and surveillance, this is a facility we can touch every day, and, so, we can place some operational conditions to ensure safety.

Safety margin and defense-in-depth can be handled a couple of ways, by the way. One is choosing codes and standards, commonly used. We would like to help ourselves in the licensing process by using existing codes and standards that the NRC is familiar with. And the defense-in-depth, we will probably do some barrier tech analysis again.

So, what do we do for the postclosure? Site characteristics and engineered barrier design, we do the analysis, we do the performance assessment. Identify credible features, events and processes. Get our scenarios, probability, assess consequences, evaluate the expected performance. Same chart, only this for the postclosure. We compare with the standards and assess uncertainties. We go over and look, what can we do to improve the PA? Gain confidence, make it better.

How do we enhance our safety margin, our defense-in-depth? How do we evaluate them? Increase the information about potentially disruptive events. Increase natural analogue information and update the performance confirmation plans, what should be done next.

Now, Rev. 2, the principal factors, as I said, and I will go through this quickly, because I have covered some it, nominal case factors, all that might play a role. The drop of water moving through. There was no consideration of disruptive events. The performance assessment was the VA design and the VA models. And what did we do? Well, we decided we had better look at safety margin, and we had better look at defense-in-depth and some of the other elements of the safety case, because at this point we are working almost purely with the PA, the performance assessment.

It is noteworthy at this point to identify the attributes of the system, because the attributes of the system haven't changed in years. And the attributes are to limit the water contacting the waste package. They are to have a long-lived waste package. To keep the waste inside the engineered barrier system, inside the drift area, near-field. And to identify and understand the reduction of radionuclides as it is transported through the unsaturated zone and the saturated zone out to the receptors.

Those four things, those four pieces of the strategy have no changed over the last many years. The approach is still the same. Which factors, which models and how they have evolved has changed a bit. But the basic approach has not changed.

In Rev. 3, it is important to see Rev. 3, the principal factors, we made some subjective judgments about the factors expected to be the most important to performance, and they were supported by the barrier neutralization analysis. What we did was is we sat down the PA analysts, we sat down the principal investigators, we sat down this preliminary PA that we had done, we did these barrier neutralization analysis, non-mechanistic cases. What if there is no rock above, and it rains right on the package? What if there is no package? Those types of things. Classical "what if." And we went back and asked questions of these people. Do you think we got this right? Did we not get it right? How does this do this? And this was important and we spent the time with those people because it, in fact, did point the way at where we spent our resources in the last two years getting ourselves ready for the SRCR.

Our performance assessment was this design, we used the VA models for the natural system. And what did we do? We did the preliminary consideration of safety margins and defense-in-depth, that was the barrier analysis, in particular. And we put out Rev. 0 of the performance confirmation plan, which basically said, what might we need to measure and how can we measure it? Very broad scope, not a plan as much as a capability document to be able to look at things in the future.

Rev. 4, the principal factors are being developed following the risk-informed, performance-based approach, which I will describe. We did our first full evaluation of features, events and processes. We went through every portion of the system, international database, and worked through what features, events and processes should be considered and marked them in or marked them out, documented that. That has been -- some of those have been reviewed. We are supplying some of our technical material to the NRC staff, and they have looked at those and had comments on them, and our documentation probably needs a little tightening up, but we have done that -- or we are doing that.

And this is, however, the first full evaluation of features, events and processes. Up until this point in time, the PA analysts generally tried to make a good guess at what it was going to be. They documented what and why. This time we did it a different way, and that different way was our updated models are fully documented in the process model reports and the analysis and model reports. We have done a lot of science on this over the years.

What we imposed in this past year, or past two years, has been an architecture of these AMRs and PMRs, where we have broken it down into the models that go into the PA, and we have assigned a lead to every one of those models in the scientific community. And he has on his team, himself, that is the scientific lead, he has a PA analyst for that area and he has a regulatory engineer to assist him to make sure we answer the NRC's questions, and to make sure we have the integration between the science and the PA.

We wrote RSS 3 and said, here is the basis that we want you to follow. These can be simplified. These should be more realistic. And they followed that basis in terms of putting together some 122 AMRs which together, including FEPs, AMRs, process AMRs and abstraction AMRs, put together all of those pieces in a unified approach to get the models pulled together for the TSPA and to create a PMR that shows how you derive from what you learned in the field to how you model in the TSPA.

So, we have, as it says, fully documented, it is fully traceable, we can explain why we did what we did. We will probably have lots of arguments about that, but we can explain what we did, why we did what we did. The FEPs are fully involved in that piece. And, in fact, it followed RSS 3 with pieces of bounding or pieces of full probabilistic.

Now, you will notice it says the analyses address a range of uncertainties. This may or may not be the full range. The unsaturated zone leader will tell you that he has simplified how he has gone about doing seepage. It is not -- you know, it is skewed so as to be defendable. I think that the waste package people would tell you the same thing, that they have skewed it a certain extent to be defendable.

CHAIRMAN GARRICK: What are they saying? Are they saying they have made a distribution curve conservative to be defensible?

MR. BAILEY: Yes.

CHAIRMAN GARRICK: That is bad. The whole idea of risk modeling is to tell it the way you believe it is and what the evidence can support, not some fudging to the right or to the left on the basis of trying to win a case. This is just a sore point that those people who are practicing risk assessment and start monkeying around with distributions on the basis of hunches or what-have-you, and changing them, and that that change is not supported by tangible evidence, are violating the most fundamental rule that exists with respect to risk assessment.

MR. BAILEY: I understand the sore point, and let me see if I can clarify. What they have is, in fact, fully supportable and it is not a hunch. It is, however, perhaps not the full extent, it is supportable. There are no hunches, there are no -- well, we are going to put it over here because we don't know anything. It is we know that we can defend it being here, and here is the data that can support it being here. Could we defend it to be more? Perhaps. I do understand the sore point.

TSPA includes both the nominal and igneous activity scenarios this time. We did pick up one of the disruptive events.

What measures do we have? Full evaluation of the safety margins and defense-in-depth will be done when RSS 4 is done. And Revision 1 of the performance confirmation plan goes back to the repository safety strategy Rev. 3, since one of most important things to measure are the things that we want to be confident of, and starts to focus the performance confirmation plan on the most things to review.

MR. LEVENSON: I have a question about that.

MR. BAILEY: Yes, sir.

MR. LEVENSON: You use the term "full evaluation of the safety margins." That implies that you are keeping track as you go about the conservatism and every component, and that you are going to add them up at the end. Is that really what you are doing?

MR. BAILEY: No, sir. You saw a slide in Paul Harrington's discussion that said we need to do a better job of that than we are doing. This is a full evaluation based on what is in there and then the back end look at it.

What did we do? That is what we did, the same thing that I said. It comes over to principal factors and then we try and find some specific vulnerabilities. Where do we think we are weak? Here is an example of features, events and processes evaluation. We have a waste package. We numbered all the FEPs so that we can track them and find why we did them like we did. We have a title. We went back over to which process model factor we fit them into, and you can see we have some that fit and we have some that we have excluded.

This is an example, these are, in fact, documented. One that is kind of interesting here, mechanical impact on the waste container, effects of rockfall on the drip shield or on the waste package. Even if the drip shield is not present, excluded by design, -- it caught my eye. I expect it caught yours. It will show up again in a couple of minutes, if I can beg your indulgence.

Again, the documentation that we have been providing to the NRC Staff, which I presume you have access to, contains the AMRs and the FEP analysis that would support these in particular. We will be having a lot of discussions over that.

So what were the process model factors that we came up with for the nominal scenario? We had flow, which included -- and you go back to the lists -- climate infiltration unsaturated zone flow seepage, thermal effects, the environments, the drip shield and waste package performance, the wasteform performance, the concentrations dissolved and colloid associated, the EBS radionuclide transport, the transport in the UZ and the SZ, and finally the biosphere dose conversion factors.

CHAIRMAN GARRICK: Jack, when you use the words "credible factors" you are suggesting that the issue of likelihood entered into the decision as to what you consider and what you don't consider, and when the issue of likelihood enters into it, the issue of probability is an inherent part of it.

Is that a formal process?

MR. BAILEY: Yes, it is. It is a formal process in accordance with the regulation, which tells us to conclude one of three things.

First, does it meet a probabilistic rate of occurrence,

Second, you look at it from a systemwide basis.

Third, you look at the consequences.

You go through those three screens and that is why you see some of these FEPs, Features, Events and Processes, that we probably did screen number three without having run the TSPA -- judgment as opposed to numbers.

CHAIRMAN GARRICK: Thank you.

MR. BAILEY: For the igneous case, and all this is preliminary I remind you, we looked at the igneous activity factor. It was kind of interesting. You have a probability of the igneous activity. Does it even occur?

The magma intrusion characteristics -- how does it intrude into a drift? Does it erupt down a drift, does it flow down a drift, what exactly is the energy content? That makes a difference in terms of how the waste package and the waste respond; the response of the repository to the magma intrusion, as I just said; the UZ flow contacting the waste -- if you damage the packages, now you are back into -- your engineered barriers are gone and you are carrying it straight through with UZ. The concentrations, how does it get into the system? Radionuclide transport in

UZ and SZ.

Then of course you have two biosphere conditions. One is an inhalation pathway and one is an ingestion pathway. You have to consider and combine them, which is different than the water-borne pathway that we have been concerned with in the nominal case so we pick up a few more things that we have to work on in order to answer those questions.

TSPA, as I said before, is our basis. We look at sensitivity studies, barrier importance analysis and try and bring all that together.

We have been holding a series of workshops to work through the features, events and processes to work through our understanding of the system. We have another workshop in a couple of weeks which is going to be the workshop where we actually get TSPA results in sensitivity analyses and it will be a well-attended workshop but a large number of PA analysts and principal investigators in order to understand the results and have the discussion of what does it really mean.

Now the approach changes focus from the subjective judgments to the specifics identified. What does the math tell us? What does it mean?Do we have the data to support it?

The approach also helps ensure consistency and completeness. It also makes you look at the whole system. You have to find a way to look at the whole system.

In simple form, the VA, we looked at everything -- what can we learn about it, how much more can we learn, and how do we represent it?

In Revision 3 we went back and found seven principal factors, which we discussed several times.

RSS-4 pretty much ratifies that. You will notice the colloid-associated radionuclide concentration has come back on the screen based on investigations in the last year.

DR. HORNBERGER: Could you tell us, the ones that popped back up, could you say just a few words as to why they popped back up? Colloids in igneous activity is what I am interested in.

MR. BAILEY: I'll go back to the igneous activity. It is the first time we have analyzed it, to be honest with you. It just hasn't been analyzed because we have always done a nominal case up to this point in time.

Part 63 says that we have to include the disruptive events along with the nominal case and so we had always done the disruptive case separately and now we are putting them together. That is why that one shows up.

The colloids was in fact an issue back in this timeframe and we didn't have enough data to kick it up or not kick it up. We kind of left it in the dissolved radionuclide concentration and now that we understand the issue better, we believe it deserves its own name so that we can keep track of the ongoing development.

What this says is that we have chosen a path and the math still seems to support that. The naysayers may say, well, you chose a path and you are making it work. We don't believe we are doing that. We believe that we have adequate understanding in these areas. We believe we understand them. We believe we have confidence in why that is and that in fact what we knew a couple years ago, after many years of study, and now some concerted effort to put it into place, stayed about the same.

DR. HORNBERGER: Jack, before you leave, there was one other than fell into that category and that's the biosphere dose conversion factors that fell off in Rev. 3 and came back in Rev. 4.

MR. BAILEY: You're correct. I'm sorry. The biosphere dose conversion factors was in Rev. 2 because there were ways to put the biosphere together at the back end of the system. There were different ways to do it and how you put it together was important.

In Rev. 3 it came off because the regulation specifies how it is to be done.

In Rev. 4 the igneous activity is not specified per se because it basically specifies an aqueous ingestion approach and if we in fact have to deal with an eruptive event then you have got to look at the inhalation as well, so it came back because of that.

Then we said let's look at barriers. Wet makes the difference. Wet gives us a 1000 year holdup time, 1000 year delay or a 10 to the minus 4th reduction in radionuclide transport, and these are the things, the overlying rock, the drip shield, the waste package outer barrier, the UZ, the SZ transport.

There are some other barriers and this come back to Dr. Garrick's hot spot of why aren't they in there? That is the waste canister and the waste package inner barrier. Both of them are metals. They are not particularly robust metals in this environment, and so we don't model them. Does that carbon steel inner lining fall off the moment the outer lining gets a pinhole in it? No, but conservatively we don't try and make that modeling. We do look to see if there is deleterious effects because of it but we don't try to model it, but in actual fact the inner barrier is there and the defense high level waste in particular is inside a canister, which takes some period of time to fail.

We look at cladding. How much credit do you get for cladding? That is probably a good example of part of the problem in the probabilistic approach -- at the risk of going to the hot button --

[Laughter.]

MR. BAILEY: -- and that is clad's there. Clad's there. I have the same problem. Clad is there. You know, we have a fairly good understanding of clad because it was manufactured with certain requirements. It was handled by the utilities and they know what happened to their clad, at least during operation. It's now been in a pool. It's been transferred perhaps to a canister. It's been transported. The question that is unanswerable is what is the condition of the clad when you receive it, because you have got to go through a corrosion calculation here, and what has happened to it over that timeframe.

When you have got 17 by 17 roughly, 289 pins per element and you are handling hundreds of thousands of elements, how do you sample that. How many of those do you have to rip apart? How much sampling do you have to do?Different utilities, different handling, different scenarios, different burnups, different smelts of the zirc. It becomes very difficult to come up with a realistic or an exact initial condition and so you select one that bounds it. Is it as good as the real one? Probably not.

The drift invert may have some capability if we engineer it correctly in conjunction with the drip shield we may be able to get diffusive transport and really get a much slower movement through the EBS which is both retardation, decay, and delay. We haven't tried to do that at this point in time. In fact, we basically let it out of the drift very quickly right now, so there are some other barriers that may be important that we haven't gone full up on yet.

Coming back to that vulnerability word, and that is now that we have some analysis, and this is what has come out of the workshops, what do we think are the problems with what we have done to date?

Well, oddly enough, inadequacy of the treatment of model uncertainty -- Paul talked about that. We are taking some action. We need to increase the consistency of the treatment of uncertainty. We need to mitigate uncertainties to defense-in-depth. That is a way to deal with it if we have high uncertainties that we can't learn any more about -- we may understand them but we may not be able to make them go away -- and lo and behold, maybe we better ensure the effects of rock fall are analyzed, if you go back to what happens with designing a way rocks falling on the package. The question in the workshop was maybe we haven't covered that one quite right yet, so we are going back to look at that.

DR. HORNBERGER: Jack, when you go back to look at that, I know Paul talked about a really huge rock. Now our friend Charles Fairhurst tells us both that that is an impossibly large rock, that the rocks that really come out of the roof are not going to be anywhere near that huge. Are you going to actually again try to do this a little more realistically when you go back and look at it?

MR. BAILEY: Yes. That is part of the issue. The rocks that will come out of the roof we believe will be much smaller than the one that -- I didn't hear Paul's particular talk. I didn't see the size but I think we are going to go back to try to look. Hopefully Paul will nod that he agrees. That is our intent. We took a very conservative approach.

We have some overconservatism in some models. There is no question of that. I think wasteform is one of your absolute stellar examples of that. The waste is in fact inside of zirc. It is a metal oxide. When that first drop of water penetrates the package we consider that the entire exposed fuel, whatever we choose because of the clad assumption, is immediately saturated.

That first drop of water goes a long way. Not only is it immediately saturated, it is immediately equilibrium and it is available for transport back out through the same hole that it came in as soon as the next drop comes in. Very conservative.

Can we do better than that? Probably -- but we haven't yet.

MR. LEVENSON: I have to object. You punched my button.

[Laughter.]

MR. BAILEY: Okay. Good.

MR. LEVENSON: Overestimating the consequences so severely is almost never conservative because it causes you to make other decisions and do other things which have their own risk.

MR. BAILEY: Yes.

MR. LEVENSON: And when you severely overestimate by many orders of magnitude a consequence -- sometimes you have to because of uncertainties, but when you do things that are ridiculous you seriously challenge your credibility in other things you are doing.

MR. BAILEY: I understand that, sir, but we do a number of overconservatives and that is in fact the word we chose. There is some overconservatism that we would like to take out.

We believe our answer is in fact overstating it but --

CHAIRMAN GARRICK: Of course, it is important here to know what the intervening events are. Sometimes in the case of cladding on fuel and a reactor loss of coolant accident, who cares? It doesn't make any difference what the quality of the cladding is, and that is because once you lose the coolant you lose all hope of integrity of the fuel anyhow.

MR. BAILEY: Right.

CHAIRMAN GARRICK: So it really depends upon what the intervening events are and this is something that has to be picked up in the FEPs, I guess, since you don't seem to employ the more traditional approach of risk assessment, namely a scenario-based approach where you can clearly see the sequence of events that are taking place and have a basis for judging what these intervening conditions might be.

Now you must have them in your FEPs analysis and in your process models, but it is something that has to be taken into account because if you start isolating these and say you are conservative on these out of context, it is a lot like in the old days in the reactor PRAs where people would say, well, we have analyzed System A, System B, we have done the fault trees on them. All we have got to do is connect them together and we have a PRA. The answer is you absolutely do not --

MR. BAILEY: Right.

CHAIRMAN GARRICK: -- because the boundary conditions of those systems are very dependent upon where they appear and what they are asked to do in the sequence you happen to be in. That is very boundary condition dependent, so this is something we were talking about during the break that we really have to take a very hard look at is this whole issue of the uncertainty analysis and how the uncertainties are aggregated.

MR. BAILEY: Yes.

CHAIRMAN GARRICK: And whether or not there is indeed a structure or a mechanism with which this aggregation makes sense.

MR. BAILEY: Yes, sir. I don't disagree with you.

MR. LEVENSON: A slightly different question. Listening to your discussion about the complexities of the state of the cladding, and I appreciate and understand that exactly, but if I now go back into the model, has that been carried along or will I find that in the model the assumption is made that all the cladding fails coherently at the same time rather than over an extended period of time?

MR. BAILEY: I have to think. I believe that the way we have clad modeled now is that there is a certain amount of clad that is available and then it fails through two or three different mechanisms. Some of it is corrosion --

MR. LEVENSON: But all at the same time?

MR. BAILEY: No. Some of it corrosion, some of it a splitting, if you will, and I think it is in fact time spaced. I believe it is. I will have to check on that for you, sir.

You have two vulnerabilities the team has identified -- we'll have to work on it -- the thermal loading issues which Paul talked about at some length. Those of course make a difference in how you do your modeling, perhaps not to the overall result but certainly in how you do your modeling so we have to be alert to it.

The potential for igneous activity at the site -- we have to go through. You saw the new chart of all the pieces that are there. We really have to solid that up.

The reliability of the complex metal barriers -- the waste package provides a lot of performance right now. I think Paul described a number of the modeling pieces that are in there. We are looking at general corrosion. We are looking at stress corrosion cracking. We looked at microbiologically induced corrosion. We looked at small weld failures inside the package that help, if you will, accelerate the failure of the throughwall of the package.

We have got a fairly comprehensive model in there but metals are tough, and so we need to look.

Consideration of peak dose -- peak dose is pretty far out. As you might expect -- go to Dr. Garrick -- running this model for a million years isn't how the system works. This has FEPs that are in the 10,000 year timeframe, not in a million year timeframe.

The conservatisms we placed there for a regulatory basis, if you will, for 10,000 years is probably inappropriate out hundreds of thousands of years. That is a long way out. We are looking at how do you make a licensing argument in some of these in taking some conservative stances that probably aren't appropriate, so we have to think through how to deal with the peak dose because it is in fact a different analysis.

Now, if you work this back the other direction, which is the five pieces of the safety case, the quality of the performance assessment, we need to address the issue of uncertainty. There is a confidence issue there.

Dr. Levenson has suggested that conservatism may, in fact, not build confidence, it may, in fact, hurt confidence. We need to finish our FEPs.

MR. LEVENSON: Not conservatism. Severe, over-estimating consequences, which is different. You need conservatism.

MR. BAILEY: Yes.

MR. LEVENSON: But you need to know what it is, it needs to be a defined safety margin, you have to understand it.

MR. BAILEY: Okay.

MR. LEVENSON: Just throwing in over-estimates wherever you go is not conservatism.

MR. BAILEY: That's fair. That is also a good clarification. Thank you.

I think he is working on his tapes. I'm sorry he missed that.

And we need to ensure a consistency in the overall uncertainty. The safety margin and defense-in-depth, we don't want the single failure point. It is a system, the system needs to be used in total. We need to evaluate the designs to look and see what we can do with the defense-in-depth aspects. And we need to look at the confidence in the process models that we are putting in there for defense-in-depth, not just throw them in, but really believe that they work.

The explicit consideration of potentially disruptive processes and events. We have got to finish our evaluation of the features, events and processes, document our basis for excluding others, the criticality, seismic activity and water table rise, which we have excluded from this particular runs of the TSPA, although we do consider them as additional runs to show what would happen. But we don't believe that they occur and we need to document that.

And we have got to finish the igneous activity and, of course the human intrusion scenario, now that it is being defined by regulation.

Insights from natural analogues. Obviously, it would be nice to get some metal passive layer knowledge, better knowledge on the transport models and the effects of heat on host rock.

There was a question earlier about, are there any natural analogues for the Alloy-22? And I can't pronounce them, I am not a geologist, Josephenite, I will just take a stab at it, is apparently a nickel/iron, naturally occurring mineral that may or may not have some capability in that arena, and we believe we ought to go take a look at it and see if, in fact, it does work as an analogue and if we, in fact, can learn something. There will probably be a recommendation from the repository safety strategy.

Pena Blanca, looking at what we are doing in Busted Butte, the analogue volcanoes, so we get better knowledge of what is really out there.

And, finally, we called it safety assurance here, it should be the performance confirmation, but they are trying to making a point that, in fact, you are going to do performance confirmation testing. You always have retrievability available to you during this because of the regulation. You have to make a closure decision at some point. Why? What is the basis for it? And there is a requirement there for some postclosure monitoring. So, you really have four thing that you are working with institutionally before you can make your decisions to close. And, of course, we want to go back and work the performance confirmation plan.

Now, there was another piece on the agenda that talked about the relationship between the RSS and the KTIs, and I have a couple of pages to just go through that quickly. Obviously, working the repository safety strategy, which is the whole system, touches or runs across the KTIs, which are the NRC's key technical issues. So, we cross-cut them as we walk through all of this.

Several of the KTI subissues are closely linked to the principal factors, the things that we find important, the things that we find really control performance. Some of them, where detailed questions are asked, we don't find make a lot of difference to performance, and that, in fact, we may have enough knowledge now to move on from there.

And we have been discussing this, I think the next slide does that. No, actually, the next slide tries to give you a relationship between the KTI and what our principal factors are. And what we are telling you here is that in the radionuclide transport arena, the thing that we consider important out of that KTI, and before the staff gets too worried, on a gross scale, it is the retardation pieces that are most interesting.

The rest of the radionuclide transport is not as significant as those. And, so, that is the simple purpose of this table, is to point out the KTI. And what is shown over here are those portions of that KTI or our principal factor, which could be related back, is what we think is really important to that, and other items are of lesser importance.

Plans for addressing the individual KTI acceptance issues obviously come from the RSS because that is our basis of what we think is important and where we are going to put our resources. We need to focus work on the LA on reducing uncertainties in the areas closely linked to performance. As I said, we will tend to bound or to simplify in other areas. And the information that we intend to provide for each subissue will reflect the importance of that subissue to the safety case. That is our strategy.

We had a technical exchange with the staff on April 25th and 26th. It was kind of one of these. We told them what our -- what we thought we were and what we thought were the principal factors, and they told us theirs. And we go some alignment and some misalignment, and we have a whole series of meetings throughout the summer and fall to come back, basically, to the process model report, is how we chose to focus it, because that is our summary document, and work backwards, if you will, to make sure we get some alignment on what the KTIs and the principal factors and the factors are. And those meetings will, hopefully, make that happen so that we can have the meaningful discussions to try and close on it.

Preclosure safety, I will talk to very quickly. The same chart, you do almost the same things. You evaluate your hazard, you select your category 1 or 2 in accordance with the regulation, and you find your design basis events, and you find out what you need. Your strategy, you do prevention. Keep it from happening. Paul talked about it today. Don't do a lot of lifts, you know, kind of shimmy it up and shimmy it down if that is all you have to do. Open something and push it up and close it. Try and get into prevention. Don't let the event happen. If it has to happen, find the best way to mitigate it.

And, of course, you can go back and modify design or you can modify operations in order to control those items. Feed it back, get it into the system, and, again, it feeds the safety case, the requirements, and the Q-list. Make sure that you put these pieces together. And, of course, out here, now that you know this information on frequencies and importance and what it contributes, you can start getting into grading. So, you can get the classification and then you can get the grading.

How do you do it basically? I don't think there is any revelations here. You have to look at your external events, your fires, your tornadoes, your tsunamis. Tsunamis probably won't make it. Determine your project applicability of the events. Does it exist? Is it operative during the preclosure? No. You screen it out, define why. Yes. How do you handle it?

External events, obviously, are problematic, you can't prevent them, but you have to mitigate them.

Come back to the internal. The internal, obviously, has to do with what your design looks like, what your operational modes are, how you put the system together. It is design-dependent. And you go back, you determine your design and operational features.

We chose to put a big emphasis here on the energy source. What is it that makes the radionuclides become active? This is really a fairly benign facility, this is not like a reactor with high pressure, high temperature. This is move some stuff, it is not -- you know, it is material that has to be respected, but it is not a high energy material at this point in its life. And, so, we obviously want to put a lot of energy into not having a lot of energy. That is part of the prevention strategy. So, you look for it. If there isn't an interaction, then you are okay. If there is, then you start looking at -- how do you put these together? How do you come up with your design basis events? Where can you do prevention and mitigation? And pull that together.

So, what are the decisions? Well, what the RSS will give us, postclosure, preclosure assessments, mitigation, additional information. Consider the feasibility, any other factors that we need to go work at. Work on the safety case for the LA. How do we put it together, get our confidence? Develop the requirements based on the safety case, so that we can go back. As Paul said, they want to do some different work in the fuel handling building. We need to work on how to go about that. And, finally, get the Q-list, so you can get into the system, structure component portion of this if the site recommendation is advanced and told to continue.

We are in process. I expect that late summer or early fall, we will be able to get a pretty good view of what the results are. I can't commit to that, that is a rough schedule, in that timeframe. But I expect that is the next time when there is a meaningful update on actual progress of this document.

DR. HORNBERGER: Thanks very much, Jack.

MR. BAILEY: You're welcome.

DR. HORNBERGER: I am sure that there are some questions, I think. Let me start. I want to -- I accept your point, -- go back to the fact that igneous activity popped up in your RSS Rev. 4 preliminary. And I accept what you said, that this is the first time that you have included this in the analysis. However, it strikes me that it is, in part, based on preliminary results that you have seen.

MR. BAILEY: Yes.

DR. HORNBERGER: Which might lead one to think that the way that you have modified the analysis post-VA, mainly in response to NRC's staff urging to use the ash plume model and you had the size of the material too large, possibly, your preliminary analysis suggests that you do have to look at this and that it isn't a no-never-mind. Can I take that as the status? Am I reading this correctly?

MR. BAILEY: We have modified the analysis. Analysis was, in fact, performed to the viability assessment, which I think is what you are referring to.

DR. HORNBERGER: Well, it was performed separate.

MR. BAILEY: Yes.

DR. HORNBERGER: But the NRC staff had some major issues.

MR. BAILEY: Yes, they did, and they made some comments in many of the areas that you have suggested, and we have gone back and put some of those changes in the model, and see what the model results are. We have not yet agreed that those are, in fact, the right changes to make to the model. But now with the NRC's approaches and their beliefs in how this looks, yeah, we have to look at it.

CHAIRMAN GARRICK: I am curious a little bit about how you are going to use the RSS as -- are you going to use it as kind of a management tool, or is it principally documentation of the strategy? What function is this document doing?

MR. BAILEY: It does both. It does both. It has to -- let me see if I can explain this correctly. It does the evaluation of the technical work of the TSPA. It is intended to put the meat on the bones of the safety case, so, this is how we would make these arguments. It then sets up a strategy of what are the next things that we need to work on based on the way we want the safety case to come out. And it is endorsed by the DOE management through the process. And when that happens, it becomes the planning guidance.

And, so, it does both. It lays out the strategy of what we intend to rely upon, the basis for that reliance as it comes through the analytical basis. It lays out how we are going to accomplish that, and then it lays out where we need to go do more work, which becomes a planning basis.

CHAIRMAN GARRICK: I guess for those people who lack confidence in the performance assessment process, and I am not one of those, --

MR. BAILEY: Yes, sir.

CHAIRMAN GARRICK: -- it answers the question -- what else is being considered for the safety case beyond the performance assessment?

MR. BAILEY: That's correct. That's correct. It says there is four more things, take a look at it. Now, you could roll -- I will go back. I will show the right slide, it is the next one. If we stick to whichever side this is.

The PA is your mathematical representation and all the sensitivity studies that go with it to gain that understanding. It is not just a squiggly line, it is, in fact, the understanding.

We chose to segregate safety margin and defense-in-depth. This treatment of uncertainty, conservatism, how much do we have, and doing an analysis. Perhaps in a manner here for the defense-in-depth, it is not purely probabilistic. It probably will be a stressing of the system to see how it responds. You could call that a sensitivity analysis, but we believe it, in fact, is a means of stressing the system to make sure that you don't have any single dependencies.

The insights from natural analogues, that could be rolled into the total system performance assessment and, obviously, will be, as part of the basis for how we chose the probabilities that we used inside of there. But we felt that it was appropriate to separate it and give it a higher level of visibility so that you can see that some of the results, in part from this, can be related back to nature.

CHAIRMAN GARRICK: Yes, I would hope, though, that those who are raising the question about what else are you considering would appreciate the fact that what you mean by total systems performance assessment is the consideration of any evidence that would in any way impact the performance of the repository and would have something to do with the quantification of that performance, and that is all those things. So, I don't see those as separate and independent issues.

I would think that, to the extent that natural analogues tell you something about the long-term performance of the repository, that has to be a part of the TSPA.

MR. BAILEY: It does.

CHAIRMAN GARRICK: I would think the extent to which measurements are going to be made or monitoring is to be done, that has to be a part of the evidence base that you have for the TSPA. So, to me, this is all sort of an artifact of displaying information for people who are asking questions who don't have confidence in TSPA or don't understand TSPA, which should include every one of those things.

So, anyway, but that is --

MR. BAILEY: It is, in fact, communications.

CHAIRMAN GARRICK: Right.

MR. BAILEY: I don't argue that at all.

CHAIRMAN GARRICK: Right.

MR. BAILEY: In fact, I think I made the same discussion, that each of these could be and should be, in fact, found inside of there.

CHAIRMAN GARRICK: Right.

MR. BAILEY: But you break them out in order to show the layering.

CHAIRMAN GARRICK: Sure. Sure.

MR. BAILEY: That it is in there, it is ragout, right, it is in there, but let's bring it out and show you that we have tomatoes and peppers.

Well, I am reassured to know that you understand that, because there is no bounds on what you put in a performance assessment. It should be everything that has anything to do with, in any significant way, in a visible way, with the performance of the repository. And all those things are in that category. Okay.

DR. HORNBERGER: Just one quick follow-up on that, if I may. Is it your understanding, Jack, that this list, in fact, then would satisfy the TRB, in particular, who has said that you need something more than performance assessment? Is it your understanding that this is what they mean? It is hard to put Jack on the spot, he is very nimble.

CHAIRMAN GARRICK: I didn't want to name names. George has named names.

MR. BAILEY: I want to give you a responsive answer here. To Jack, this communicates very well to me. I am a deterministic guy, I will admit it. I think I understand probabilities on odd-days, odd-days of the week. But, to me, this communicates. It provides that layering. It brings it out in a communications manner. I mean we can find all of these things.

Now, for example, the barrier analysis, neutralization analysis, is kind of an example here. The neutralization analysis is probably not really part of this because there is no case where the overlying rock isn't there. You know, it might be a .00001 that it isn't there, but there is not a zero that it isn't there. And, so, in that one area of neutralizations, it probably isn't necessarily part of the TSPA.

But, to me, this communicates. It says, I have got the math and I have put the system together and I have learned from it. It says, I know I have got a separation, I know I have some margin. I know it is going to work better than -- I know it is going to beat the regulation. I have, like I said, I am a deterministic kind of guy, I like to go "what if." You know, what if I step on the brakes and it doesn't work, what do I do next? Do I downshift? Do I pull on the brake that has a wire? At least I hope it still has a wire. I know what I am going to do next.

The analysis of potentially disruptive events, it is a classical, of course, which is the low probability, high consequence, and people, I find people think like that. I do. What is the worst thing that can happen to me?

In here, it is just part of the curve. Now, is it in there? You bet it is in there. The analysis is there, you can pull it apart. This displays it. And I think this answers the questions that deterministic type people tend to answer, and create that layered argument that says, yeah, we have a probabilistic view of it and we also have some other views of it that lend some confidence.

CHAIRMAN GARRICK: We keep making it difficult to communicate what we mean. There's another one out there, too, that clouds the issue, and that's the Integrated Safety Analysis. I, for the life of me, don't know what gave that a berth, because the ultimate integrated safety analysis is a PRA.

MR. BAILEY: Yes.

CHAIRMAN GARRICK: And so integrated safety analysis has to be a subset of that. But, nevertheless, if it enhances understanding and communication, you know, it has its value.

But at the same time, we shouldn't misrepresent it. We shouldn't lead the Technical Review Board or anybody else to think that PSA, TSPA, is bounded or PRA is bounded.

It all depends upon what we have identified as our performance measure or our risk measure. With respect to that risk measure, it should be totally unbounded.

Now, we may not have identified enough risk measures or the proper risk measure, and that's another issue, but to the extent that you identify one, then the analysis has to include everything that affects that measure.

MR. BAILEY: Oh, yes. I would not even suggest that the TSPA doesn't include this.

CHAIRMAN GARRICK: Right.

MR. BAILEY: This is a representation of that external for communications.

DR. HORNBERGER: Okay, good.

DR. WYMER: John sort of stole my thunder, but I'm going to go ahead anyway.

MR. BAILEY: Can I give the same answer or non-answer?

DR. WYMER: I'll get to a question eventually.

[Laughter.]

DR. WYMER: It's clear that the RSS is central to the license application, and it's really needed to get on with this whole business.

But unless there is feedback from this activity into the design or the analysis or request for additional data, it's a passive exercise with respect to what you're doing in building the repository.

So the question then is what formal mechanism is there for feeding back the results of the safety analysis, and what's the documentation of that formal process?

MR. BAILEY: It goes into the planning guidance for the upcoming year. The RSS is published, signed out by the Department of Energy's management. It says here's our path forward.

And it provides guidance, on, factor-by-factor, what we need to know, what we think we need to work on, what the minimums are to do in those areas, and where we want those results, if you will -- not predetermining the results, but what basic answers we want those results to provide us.

We'll let the chips fall where they may, but this is the part of the puzzle that you have to fit into, and it goes into the planning guidance.

And that's what gets funded, and that gets reviewed by all levels of management, including DOE, to say this is the right work to do.

I can guarantee you that when the RSS is issued, people know it and it has an effect.

DR. HORNBERGER: Thank you. Staff, anyone with any questions?

MR. LARSON: I have a question.

MR. BAILEY: Yes, sir?

MR. LARSON: You know, reactor safety strategy, I assume that it's based on the Part 63 is going to be your basis, but does it include a contingency, should EPA's 197 standard require changes to Part 63, or is it so broad now that it covers everything including groundwater travel and groundwater release?

MR. BAILEY: The repository safety strategy is, in fact, tied to Part 63. Part 63 will be conformed with 40 CFR 197 when the time comes. There are a few differences between the receptor. The biosphere data is slightly different in the EPA approach.

Obviously, the groundwater analysis is different or is additional, and there are some slight nuances, I believe, in the human intrusion scenario.

And we will true all that up. We chose at this point to follow 63 for the site recommendation, and we consider 197, but it's mostly focused on 63, and we'll have to true it up when the time comes and the analysis to do the groundwater can be done.

DR. HORNBERGER: Thank you very much, Jack.

MR. BAILEY: You're welcome.

DR. HORNBERGER: We'll look forward to keeping posted as you make more progress.

CHAIRMAN GARRICK: As it evolves.

MR. BAILEY: As it evolves. Thank you.

DR. HORNBERGER: So, typically, the ACNW looks forward with relish to having the chance to grill Carol Hanlon, but Carol has decided not to make the next presentation, despite the schedule, and Chris Kouts is going to deal with our very difficult questions.

MR. KOUTS: Can you hear me everyone? Am I electrified? That's good.

My name is Chris Kouts. I'm not related to Herb Kouts who some of you may know, but he did call me up once and ask me if we were related.

[Laughter.]

MR. KOUTS: Kouts is a shortened Greek name, so I think his is more germanic in origin, I think.

Here we go. Okay. Today I'm going to give you a presentation on the status of the Department's effort to revise the repository siting guidelines, the Yucca Mountain suitability guidelines. Before I get into the presentation of what our proposal was, I think I ought to go back and do a little history.

I should mention also that I know the item on the agenda following mine is of most importance to everyone here, and I will endeavor to keep my remarks short.

For those of you who followed this program for awhile, you might remember in 1984 that the Department issued repository/ -- what we called siting guidelines at that time. It was based on a requirement in the Nuclear Waste Policy Act, Section 112, which indicated that the Department needed to develop these guidelines in order to select among sites for suitability -- not for suitability, but for site characterization.

Comments that we got back during that time indicated that the public wanted us also to use these guidelines for the suitability decision the Department would make, and the Secretary's decision to recommend the site to the President. So we also are going to use those guidelines for that same purpose.

Flash forward: Let me flash back for a moment. Those guidelines were originally written to select among sites, in other words, compare among sites.

We don't have -- we only have one site at this time, as required by Congress under the amendments to the act in 1987. As a result, we toyed with the idea of changing the guidelines, removing the comparative aspects of it.

We went through a series of public meetings back in the early 90s to address whether or not we ought to change the guidelines based on the amendments to the act in 1987.

We essentially came to a decision that we wouldn't change them, but we did reserve the right that we would change the -- we could change them, if, indeed, regulations, our parenting regulations, either the NRC or the EPA, did change.

In 1996, although there were no changes in regulations, we felt that we had a basis for modifying the guidelines. We went through a rulemaking, a propose rulemaking at that time which we never finalized. And last November, we issued a revised Notice of Proposed Rulemaking in which we proposed that the Secretary of Energy would use site-specific guidelines for Yucca Mountain to determine suitability.

And those site-specific guidelines essentially said that if the required evaluation showed that the proposed repository is likely to meet applicable radiation protection standards for the preclosure and post-closure periods, then the site could be deemed suitable by the Secretary of Energy.

Now, suitability, in and of itself, is a necessary, but not -- is sufficient, but not a necessary requirement for the site recommendation.

There are other requirements under Section 114 that the Secretary needs to evaluate before he makes his recommendation to the President.

So, a) if, indeed, the Secretary does decide the site is suitable, that's not necessarily -- that doesn't necessarily mean that he'll recommend the site. There are other issues that he has to take into account.

And those issues are again outlined in Section 114 of the Act. Okay, I think that covers most of that slide.

I'm going to focus more on the post-closure aspects, but our rationale for revising the guidelines essentially is to align them with the latest science and scientific analytical techniques for assessing repository performance. One of the real sore points associated with the changing of the guidelines is the removal of the subsystem requirements that were in the original guidelines.

When NRC issued Part 63 and essentially indicated that those subsystem requirements were no longer needed and that essentially we were going to a TSPA approach, the Department is basically following Part 63, proposed Part 63.

We're also following what's proposed in 40 CFR 197 which are the EPA proposed standards.

We also issued them in -- we also addressed the public comments in the 1996 proposal in our revised Notice.

Now, we are leaving 10 CFR 960 in place. We are not taking that out of play, if you will If at some future date we are selecting among sites for site characterization purposes, we will use 960 or revise 960, as appropriate, at that time.

We are recommending or we are proposing a new Part 963 to establish the suitability guidelines for Yucca Mountain.

963 presents the criteria and methodologies for assessing the performance of a potential repository, Yucca Mountain, in meeting both preclosure and post-closure applicable radiation protection standards.

The preclosure approach, I won't spend a lot of time talking about it, but it essentially utilizes a preclosure safety evaluation that is generally consistent with proposed Part 63.

Post-closure aspects essentially use TSPA, which we have been talking about this morning, and is generally consistent with the regulatory structure in the EPA proposed rule, and the NRC proposed rule, and is consistent with what the NAS suggested in their 1995 report on technical bases for Yucca Mountain standards.

The post-closure suitability criteria which we call out in the rule, are essentially represent those characteristic traits, what we believe pertinent to assessing the performance of the repository, Yucca Mountain.

This addresses essentially the physical processes of water falling on the mountain, moving down through the mountain to the unsaturated zone, interacting with the engineered barrier system, down through the rest of the unsaturated zone to the saturated zone and then out to the biosphere.

The criteria that we use are essentially the -- mirror the process model reports that we are producing for our TSPA for the SRCR, and if we go forward, to the SR.

Disruptive events, we also address, and there are four of those, which is somewhat inconsistent with 63, but we added another one.

The disruptive events that we're proposing are vulcanism, seismic events, nuclear criticality, and inadvertent human intrusion.

And these would all be part of the TSPA for evaluation of the suitability of the site.

The post-closure suitability criteria, if you're familiar with our PMRs, which I'm sure you are, you'll see how they track essentially one-for-one. For each PMR we have, we have a suitability criteria.

We opened a 90-day public comment period which was extended and closed on February 28th of this year. We received nearly 100 responses from the public, held two public hearings, one in Pahrump, Nevada, and one in Las Vegas.

We considered the comments we received, and developed a draft final notice of proposed rulemaking. That notice was transmitted from the Director of the program to the Chairman of the Commission on May 4th, in which we requested concurrence, NRC concurrence on the rule. We're following the procedural requirements of Section 112 of the Act.

In that request, we asked for timely consideration of the draft final rule, and its concurrence to allow the Department to utilize the final rule in the upcoming site recommendation process that is right now planned for this Fall.

And that's all I have, and I'll be willing to answer any questions you might have.

DR. HORNBERGER: Thanks very much, Chris. Milt, questions?

MR. LEVENSON: No.

DR. WYMER: I have just a naive question. 963 is so close to 63, why did you need it?

MR. KOUTS: Well, you could say, why did we need 960 then. Simplistically, the suitability evaluation on the part of the Secretary is an evaluation as to whether or not the site is likely to be licensed. It's a DOE evaluation as to whether or not we feel we have enough information to have a credible license application.

So it's a DOE internal decision, and it's a logical one. If the Department felt that after doing all this site characterization work, we didn't think we could meet NRC licensing requirements and the EPA standard, then why go forward?

So this is essentially an evaluation on the part of the Department to see whether or not the site is likely to be licensed in our own estimation.

DR. WYMER: But you could have made that evaluation based on Part 63.

MR. KOUTS: We could, but it created a process, and it creates a regimented process the Department would go through in order to do that evaluation.

DR. WYMER: That's the answer.

MR. KOUTS: Okay.

DR. HORNBERGER: John?

CHAIRMAN GARRICK: I don't think I have a comment, but I'll just say to Chris that the rule for speaking to this Committee is to use 50 percent of the time, not 15.

MR. KOUTS: Oh, I'm sorry.

[Laughter.]

CHAIRMAN GARRICK: But we appreciate it; it's refreshing.

MR. KOUTS: Well, as I mentioned at the beginning, I was concerned about the next agenda item.

CHAIRMAN GARRICK: I understand.

MR. KOUTS: I was sensitive to that.

DR. HORNBERGER: I just had one quick one that is really, I think, basically the same question that Ray asked. But in answer to Ray you said that this somehow creates a process?

So part of 963 is a process for the DOE internal review?

MR. KOUTS: What it does is direct the Department, under its own regulations, for the Secretary to go through this evaluation for the suitability of the site.

Now, it's arguable that we never had to go through a regulatory framework in order to do this. The original guidelines in Section 112 of the Act, never indicated that the Department should issue federal regulations on this. But we started that process back in 1984. We're going through a regulatory process on these, and for our own evaluations in order to get public input on it.

There will be, for instance, at the end of this year, assuming we go forward with an SRCR, part of that document or those -- that several-volume document will be an evaluation against the guidelines, our own preliminary evaluation against the guidelines, and we'll be issuing that for public comment.

So, we're going through what we feel is a reasonable process in order to do this evaluation, and it also allows the public to give some input, as we went through a process to allow the public to comment on the proposed rule.

DR. HORNBERGER: It's almost to keep you on a parallel track because 960 came into being?

MR. KOUTS: Yes, and we actually did get comments from certain organizations that felt that we should withdrawn the guidelines and not go through this, but we felt it was important still to do it.

DR. HORNBERGER: Okay, thanks very much. Questions from the Staff?

[No response.]

DR. HORNBERGER: Thanks very much, Chris. I appreciate it. We have another request from Amy Schollenberger to make a comment, so now would be an appropriate time.

MS. SHOLLENBERGER: Thank you.

Amy Shollenberger, Public Citizen. I just wanted to add our two cents in here. I think that it's very nice of Mr. Kouts to consider that lunch is the next agenda item and do a very cursory review of 963 as a result.

I think this whole thing is really just a farce because it is not a system that is set up to allow public comment. It is not a system that is addressing public concerns. What it is is it is moving the individual disqualifiers from Yucca Mountain so that there's no way to say that it is not a suitable site.

I think that, you know, I have heard your argument several times that you are saying the amendments to the NWPA say that we shouldn't consider more than one site, we are going to focus on Yucca Mountain but that language does not specifically say we should remove the individual disqualifiers, which are specifically required in the original Act. I think the Department of Energy's justification of doing 963 is really just that. It is a just a justification and it doesn't really address what the public wants or what is required by the Act.

Also, I think that to say that you are doing it just to bring it in line with Part 63 again is just a justification because if it is truly for the Department of Energy to look at the site and say is this a suitable site, should we recommend it, then it shouldn't have anything really to do with whether the NRC thinks it is a suitable site because, as you said, it is all before the recommendation. It doesn't have anything to do with applying for a license and I think that it is really a joke to even say that you are doing this to consider what the public wants unless you are considering the public as NEI and the nuclear industry because that is who really wants this to happen. Thank you.

DR. HORNBERGER: Thank you, Amy. Back to you, John.

CHAIRMAN GARRICK: Thank you. I guess there's been -- the question that we always have to ask here is do we want to write a report or a letter on this topic, and is there a need for one. I really thinking of not only the 963 topic but maybe the topic before as well, but let's talk about 963.

DR. HORNBERGER: No.

CHAIRMAN GARRICK: Okay. What about the other topics?

DR. HORNBERGER: I think that the other topics really --

CHAIRMAN GARRICK: The design --

DR. HORNBERGER: -- fall into some of what Lynne presented yesterday and probably will come into play in terms of the Yucca Mountain Review Plan and what the Staff is doing, so I think probably not individually but I think that they very much fit into what we seem to be planning.

CHAIRMAN GARRICK: So it is part of the aggregation of those things that you described yesterday and the preparation of some specific reports downstream?

MS. DEERING: As long as we do capture through our other means, there is not an explicit letter on repository safety strategy, I think there are some issues on for example the alignment of key -- the subissues and the principal factors. To the extent that NRC and DOE are -- I guess what I am trying to say is that as Jack Bailey pointed out, they had found some of the subissues that were not necessarily relevant to the strategy DOE is taking and at some point I guess what we would do is want to look at the Yucca Mountain Review Plan and make sure Staff has a mechanism to in fact when it reviews and is concerned about these subissues that they have a flexible approach to back off if there is a bounding analysis, for example.

We are doing that. I understand that with the Yucca Mountain Review Plan, and that is one way to capture it. That is kind of my thinking on it.

CHAIRMAN GARRICK: Well, another way to split this is to think of the repository safety strategy as an individual product and maybe if the committee had some comments or suggestions to make that would be of benefit to the Commission to address them, but as far as the design update is concerned on Yucca Mountain I don't think at this time it would be appropriate for us to comment given the heavy agenda we have over the next three months of Yucca Mountain activities in relation to the review plan and the suitability issues.

I think that if we have a comment on the strategic plan, that could be a possible source for a letter, but again I think that here we are not talking about a letter to DOE. We are talking about a letter to the Commissioners on what we heard in this repository strategic safety strategy and I don't know if there was the kind of information there that is a basis for such a letter, and I would like to hear from the rest of the committee on that.

MR. LEVENSON: On the design issue, John, we heard from DOE about work in progress. DOE has not yet made their final selections as to what is going to be.

I think it would be inappropriate for us to comment that we think things are acceptable or not acceptable when they haven't even been submitted to NRC. We don't write letters to DOE. We write them to the Commissioners, so I think this is just a status report at least on the design aspects and I don't think it warrants a letter.

CHAIRMAN GARRICK: Yes.

DR. HORNBERGER: I think the update on the design was very important for us because this is the design that we are going to see as part of the SR and therefore I think it was critical that we have that update and have a chance to ask Paul and some others questions, but I agree with what everyone's assessment is.

On the RSS the ACNW said for a long time, years, that the RSS was something that we really did want to keep tabs on.

Again, as Jack presented it, it is evolving and it is on purpose it is evolving and so I think that I agree with you that in mulling this over we have some comments sort of on the nature of a high level strategic approach that we need to make to the Commission there may be a letter.

CHAIRMAN GARRICK: Yes.

DR. HORNBERGER: I believe that we may find that this will better wait until we see some of these details.

CHAIRMAN GARRICK: Okay, so I think it sounds like the question is still slightly open on the repository safety strategy but we have other places in the net here to address the issues of design and we will do that later.

One of the things that struck me as Amy was talking earlier was the possible confusion between the notion of a flexible design and the issue of fixing the design. A flexible design can be fixed, of course, and I think that is kind of what they are talking about, but it did suggest that there might be some confusion there that somewhere along the line needs to be resolved.

I would be uncomfortable too if we were getting ourselves in a situation that this design continued its instability deep into the licensing process.

We have said and we have had working group sessions on this that there is real merit in not fixing the design too early because of things that we learn and the fact that the site characterization program is an ongoing activity and the fact that this is the first time such a license has been attempted and where everybody is learning a great deal as we go along, and I think even the National Academy of Sciences' somewhat famous document on rethinking radioactive waste management made the same point, that we should not too far in advance try to put a fix on what that design should be.

I do think it is very important that we be very clear on what is meant by that and that we not get ourselves in a position of confusing the current strategy of adopting a design that is reasonably flexible as meaning that we are going to keep the design open, so to speak, deep into the licensing process, so we may want to at some, sooner or later, clarify that issue.

DR. HORNBERGER: You have just muddied it for me.

[Laughter.]

DR. HORNBERGER: I am pretty much of the opinion, and I think that Ray asked a question I think of Paul that would reflect that, and that is that even deep into the operational period if you have surface storage and somehow you discover a better way to do something, you certainly -- and I know that you preclude this --

CHAIRMAN GARRICK: right.

DR. HORNBERGER: -- and I don't think on the record we would want anyone to interpret something that we would say that you would fix the design and freeze it and the never improve it, ever. If you can make improvements you want to have the flexibility to make improvements.

CHAIRMAN GARRICK: Well, absolutely, and even all of the things that the NRC licenses, you will find a large number of amendments and design changes associated with them.

On the other hand, there is a fundamental aspect about the performance here that we have to have high confidence in, and so there are certain parts of the design that clearly have to be understood in advance, but no, we would not want to close the door on any breakthroughs that might come about as a result of the long-term operating period.

In fact, the opportunity is kind of unique that we have a long operating period during which to do continued study and research to increase our confidence in the longterm performance and we should take advantage of that, but I think what I am talking about here, and I didn't mean to muddy it, is communication again, making it clear what is meant by what is said.

The words "flexible" and "fixing the design" could be confused.

Okay -- any other comments from either the members, the Staff, the NRC Staff, or any from the audience?

[No response.]

CHAIRMAN GARRICK: Having none, I think we will adjourn for lunch. Thank you.

[Whereupon, at 12:25 p.m., the meeting was recessed, to reconvene at 1:30 p.m., this same day.]

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

[1:30 p.m.]

CHAIRMAN GARRICK: Good afternoon. The meeting will come to order.

This afternoon we are going to talk about the status of the NRC Low Level Waste Program. The committee member that will lead the discussion will be Dr. Wymer. Ray?

DR. WYMER: This is an activity which NRC has apparently given a fairly low priority to in recent years, largely because the low level waste had to a large extent been relegated to the states and undertaken and the disposal undertaken by private concerns. An ever decreasing number of private concerns are accepting low level waste.

There is sort of a sleeper in this. If it should happen that the Department of Energy facilities come under DOE regulation there could be a substantial increase in the amount of effort required in this and, as many of you know, there was a pilot program where several sites sort of had the NRC looking over their shoulder with respect to what they were doing with handling the waste materials, but that is still in abeyance and we don't know where that will ultimately turn out, so we are looking forward to getting an update in this field.

Tom Essig, Chief of this branch, will make this presentation this afternoon. Please.

MR. ESSIG: Thank you very much. I realize that my name may be new to this committee. I came to NMSS from NRR about six months ago and at that time I came in as the chief of the Uranium Recovery and Low Level Waste Branch, so I have had low level waste responsibility since that time.

You will notice on the title slide that it is now the Environmental and Performance Assessment Branch and I will go into that reorganization, just touch on it so you understand where some of the pieces fit together and then John Greeves, when he is here tomorrow, will go into the subject a little bit further.

What I would like to talk to you about today are basically these five areas and Jim Kennedy, who is my technical assistant, will be sharing the presentation with me, so I am going to cover probably the first two-thirds and then Jim will cover the last two-thirds and then any of the really tough questions I get I am going --

DR. WYMER: That's four-thirds of a presentation.

MR. ESSIG: I'm sorry. I thought the last one-third.

[Laughter.]

DR. WYMER: I am not sure we have got enough time.

MR. ESSIG: That was a test question.

Today I am going to talk to you about the status of the National Low Level Waste Program, and by the national program we really are referring to that which is outside of the NRC that is conducted by licensees and so forth and which we regulate, either directly or through an Agreement State, and we will talk about the future of the program, some initiatives that are on the horizon and then we will talk about the NRC's program, and that is the internal resources that we have devoted to it, and then we will get into related activities and activities that involve low level waste in some way or other, like decommissioning, TENORM and so forth, and then lastly we will summarize.

In terms of the current status, this map is reasonably up to date except for one addition. It doesn't reflect the fact that South Carolina --

CHAIRMAN GARRICK: Why don't you give him the lapel mike and then he can be as flexible as he wants.

[Pause.]

MR. ESSIG: Okay. The only thing that we could have possibly updated on this would be to reflect that South Carolina is now part of the Atlantic Compact, including Connecticut and New Jersey and that just has happened very recently. In fact, June 7th the Governor of South Carolina, as I think many of you know, signed the legislation that established South Carolina as a member of the Northeast Compact and yesterday the Northeast Compact approved an order authorizing South Carolina to join the compact.

There will be some exchanges of money -- $70,000 here and $12 million there and then it will be effective and as I mentioned be the Atlantic Compact.

Now some events that have happened over the last several years -- I am just trying to summarize here on this slide -- that have happened in the course of developing or attempting to develop new sites pursuant to the Low Level Waste Policy Amendments Act or Low Level Waste Program Radioactive Policy Act, 1985, Texas, as you well know, started to develop the Sierra Blanca facility and the regulator denied the application on October of '98. Nebraska in December of '98, the regulator denied that license application. It was to be in Boyd County. Then more recently in California, the Governor announced the formation of an Advisory Group on Low Level Waste to study alternatives to the Ward Valley. Of course, Ward Valley is no longer being considered.

The last point there is a conclusion that was reached by the GAO in a report that they prepared at the request of Congress to determine the status of the state and compact efforts to develop new facilities and alternative approaches, and they have just basically concluded that efforts by the states in compact to develop new facilities have essentially stopped, which I think that would be a pretty accurate statement of what we see currently.

With the possible exception of U.S. Ecology -- I think it was mentioned yesterday in the Chairman's opening remarks -- is -- I'm sorry, I am getting a little ahead of myself. I want to talk about U.S. Ecology first. It operates a facility at Richland on the Hanford site that provides support for the 11 Western states, the ones that I have listed there that are members of the two compacts, Northwest and Rocky Mountain.

Then of course we still have the Chem-Nuclear facility at Barnwell, which as I mentioned will be part of that Atlantic compact.

The provisions of the compact, as you may be aware, are that it will gradually step down the amount of, the volume of waste that can be received at that facility until after 2008. There will be no waste received at that facility from outside of the three-state compact.

Recently the operator of the site, Chem-Nuclear, has been sold to GTS Duratek, and as best we know, that will not have any effect on the operations of the Barnwell facility. We fully expect it to continue as it currently is.

Next, talking about Envirocare of Utah, it currently accepts Class A waste along with, under their state license, and then 11(e)(2) byproduct material under license from NRC and NORM.

I believe as the Chairman mentioned yesterday, Envirocare has applied to the Utah DEQ, Department of Environmental Quality, for a Class B and C license, and I will be saying a little more on that a little bit later.

Waste Control Specialists, the other private facility in this business, is currently accepting NORM and other low activity waste for storage. It was recently discussed with the -- and then disposal in a RCRA cell -- but it was recently discussed with the Texas compact. That is still being discussed with the legislature so we are not sure exactly where that is proceeding but I think as was mentioned yesterday also we are aware that Waste Control Specialists is also considering a site right across the border from the Andrews County, Texas, site, and New Mexico has expressed an interest in reviewing the application should it be tendered, but that is about all we know at this point.

I believe our recent discussions with Waste Control Specialists indicate that that isn't moving anywhere real quickly but it still is on the horizon.

MR. LARSON: That is not an Agreement State so that would be a facility that if they proceeded ahead that the NRC would license.

MR. ESSIG: That would be a New Mexico licensee, as I understand it, if that went forward.

MR. KENNEDY: New Mexico I believe is an Agreement State.

MR. ESSIG: Yes.

DR. WYMER: Tom, let me make a comment.

MR. ESSIG: Yes.

DR. WYMER: I had a request from the audience that any time we use an acronym that we go ahead and say what the acronym stands for, because people get lost in the alphabet soup.

MR. ESSIG: Certainly -- such as NORM on the slide? Naturally Occurring Radioactive Material. Yes.

The Waste Control Specialists, whether or not that materializes, remains to be seen, but at least it is in the discussion stages..

In terms of the future of the national program, the California Low Level Waste Advisory Group has issued a draft report. They are considering four options -- shipping to other states, decaying the short-lived radionuclides in California -- in other words, the status quo, dividing the waste stream by hazard, building a short isolation facility or building and operating a new disposal facility, but the group, the blue ribbon panel that advised the Governor, made no specific recommendation on that.

DR. HORNBERGER: How does that second one provide an option? How does dividing the waste stream solve the disposal problem?

MR. ESSIG: I don't know that it particularly solves the disposal problem. It is another way of handling it. That is, they would either dispose or store certain materials in the state and then would have to -- what they didn't dispose or store there they would have to go elsewhere. Is that --

MR. KENNEDY: Yes. The principal dividing line would be the nuclear power plants on the one hand and everybody else on the other. I think in general it is fair to say that the group and the report focuses on an option whereby everyone like universities and hospitals and so forth, they would all fall into one category and potentially be managed at a facility with 100 years of institutional controls and closed up after that, and then the nuclear power reactors would be left to store it on site or put it in their containment building or something.

That basically is where the division is. It's between nuclear power plant waste and everything else.

"Hazard" by the way is defined by half-life principally.

CHAIRMAN GARRICK: It is hard to separate alpha and beta and gammas.

MR. KENNEDY: Yes. There has been a lot of debate about the recommendation.

MR. ESSIG: And then the last point there, Texas we expect will take up the low level waste issue again next January during the legislative session and they will be considering short isolation.

Back to the Envirocare situation, the Class B and C application. The state required that they do this in two steps. One was the first they had to get approval of the site even though it was, the site was already in use, but the state insisted that a siting application be tendered. That application has since been approved and then the next step will be the actual review of the license application by the Utah DEQ and then it will ultimately have to go to the legislature and the Governor.

There is a window of opportunity for doing that. The legislative session is 45 days each year, starting in late January, so if the Utah DEQ has approved and is ready to pass it on to the legislature and the Governor by late 2000 or even very early 2001 then the legislature could possibly consider it and act on it, but if they miss that window of opportunity it won't be until 2002 when that could be a reality.

The second point there is that there has been a study that was completed in September '99 by the GAO and it examined the status of compacts, the current disposal situation, and looked at alternatives for waste management including repealing the Low Level Waste Radioactive Waste Policy Amendments Act and letting private industry step in, using DOE low level waste sites. The study found that the underlying and recurring reason that no disposal facilities have been developed is public and political opposition, the number one reason, and the report didn't make a particular recommendation.

The last point on this slide is really a work-in-progress which we have been approached by the National Academy to fund a low level waste study. We are in the process of replying to the Academy. The letter hasn't been signed out yet but it is very high in the concurrence chain and it is about ready to be issued, and we will in that letter if it is issued as we understand it, the latest version of it will offer to work with the National Academy and fund at some level to be determined.

Our internal program or in-house program is, basically, the current direction that we have, that we are pursuing was established by the Commission in '97, based on a strategic assessment effort. At that point, a larger program was rejected and the staff efforts to actively promote new site development were rejected as well.

The current level of effort is about three FTE, down from what we had was five. And we were told that the staff should maintain every effort -- or should make every effort to maintain the core technical disciplines needed to assess the low level waste disposal issues and that the technical experts should be utilized in other NRC programs as appropriate. And, as you will see in a minute, we try to do just that.

I will say a word about our organization and then after I am done, then I am going to Jim Kennedy, but this is -- of course, these organizational elements are familiar to you, Bill Kane, our office director, Marty Virgilio, John Greeves, who I mentioned you will be hearing from tomorrow, and Joe Holonich, our deputy division director.

What is new is, as I mentioned at the outset, we have this environmental performance assessment branch which was formed after the uranium recovery function was moved to fuel cycle safety and safeguards, and the performance assessment function was moved from the high level waste branch to here. So, my branch then currently has the low level waste function, environmental impact statement, which is an office-wide function and performance assessment, which is a division-wide function.

And the resources that we have drawn upon currently, and in the past, of course, are Jim Kennedy, who is sitting at the table with me today, Tim Harris, who is sitting over to my left, and Mark Thaggard, whom you heard from yesterday, and Boby Eid, who has been involved with a lot of dose assessment activities, and Nick Orlando from our decommissioning branch, who frequently we view as our mixed waste cognizant person, and Mike Lee, who has also worked on some PA guidance recently.

So, that is pretty much our new organization, so, we have an environmental and low level waste section, and that is where the EIS function is discharged, as well as the low level waste responsibility. Well, it is actually split because Jim Kennedy reports directly to me and he has some and then Tim Harris has some at the section level. And Charlotte Abrams is the newly announced section chief for that. And Sandy Wassler is the section chief for performance assessment. Those were just announced within the past week.

So, with that, I will turn it over to Jim Kennedy.

MR. KENNEDY: I want to talk about some of the details of our low level waste program, both the narrow low level waste program that we define, basically, by our budget and, also, sort of more expansively, the low level waste program in general, that is, the word low level waste as applied generically into all kinds of radioactive wastes that happen to be low in radioactivity or specific activity.

First, this is the low level waste program as it is defined in our budget. Some very specific activities, most of which are performed in the division of waste management. One thing to point out at the very outset is that it does not involve any licensing of Part 61 facilities. There is a little bit of import-export licensing, but, unlike other NRC programs where the bread and butter of their work is licensing and inspection and so forth, we have none of that in the NRC low level waste program. There are no states about to submit a license application to us. We have no licenses that we have issued to states, and the only licenses for Part 61 facilities that are out there in the country are Envirocare, Barnwell and U.S. Ecology out in Washington State. So, this sort of basic NRC activity, or Agreement State activity even, is just not a part of what we do.

But we do do a number of different things. First, you are aware of the performance assessment guidance, which we talked to you about yesterday. I won't go into that, but that has been a long effort beginning around 1993 or so, and it has been a lot of work, and we are on the verge of completing it.

Another item that we have in our budget for low level waste activities is providing assistance to states that request assistance on low level waste. In the past, this used to be at times a fairly large activity. Nebraska, for example, asked for help on their performance assessment of that site. We have assisted California, actually, with respect to the Ward Valley site in a number of different ways over the years. We had involvement with Texas and all kinds of other states.

At the moment, as you might imagine, that effort is not large. We do, for example, go to low level waste forum meetings, as long as they will continue. They will have another this fall. I was out at a conference of Michigan generators at the request of the State of Michigan a couple of weeks ago, talking to their generators about all the low level waste and clearance initiatives, and so forth, that we have underway here at NRC.

But our goal is to continue to be responsive to state requests for low level waste disposal and management, given their important responsibility in that respect.

Another activity that we have is to review on-site disposal requests under 10 CFR 20.2002. That is a section of the regulations that allows licensees to dispose of their waste, not in a Part 61 facility, but by other unspecified means that we review, basically, on a case-by-case basis. Now, it may be disposal, for example, most often of carbon-14 on a licensee's site. It could also be disposals of relatively low levels of radioactivity at a regular landfill. And under the regulations in 20.2002, a licensee can submit a request to us to authorize that disposal. Tim

Harris of our staff generally does those, using, basically, the license termination rule and Part 20 as the criteria, 25 millirem per year, and evaluating it with DandD and RESRAD and so forth.

Generally, those are -- or I would say always those are not large disposals, they are fairly small quantities.

Another activity we have is to review import-export applications. We do about a half a dozen of those a year. Technically, there is not any challenge to that. The criteria in the regulations are not technically stringent because the technical criteria kick in when the waste comes into the country and falls under the control of the licensee and the disposal site. But they are important to us because they get a lot of -- potentially, get a lot of visibility, waste crossing international borders.

We want to make sure that there is a place for its disposal in the U.S. And the problem we most encounter with these applications to us is that the states that have disposal facilities, namely, Utah, Washington and South Carolina, often are reluctant to accept this out-of-country waste. And I would say probably about half of our applications don't address adequately where it is going to be disposed of, and, ultimately, they are dropped.

Another activity that we have underway is to coordinate with the Environmental Protection Agency on mixed waste rulemakings. Now, EPA, over the past couple of years has had two rulemakings underway to better address mixed waste, and let me see if I can get this right. One of the rulemakings is to allow for the disposal of low hazard mixed waste in 10 CFR Part 61 radioactive waste disposal facilities. And what they mean by that, and what we mean by that, is that radioactive waste that has small concentrations of hazardous constituents that normally would go to a hazardous waste landfill can, instead, go to a Part 61 facility and utilize the waste isolation features in a Part 61 facility to not only isolate the radioactive waste, but also the hazardous waste constituents that are in it.

The converse to that rule, or the flip side of that rule is to allow low activity mixed waste, or low activity high hazard mixed waste to go to a Resource Conservation and Recovery Act, Subtitle C, hazard waste facility. And the same idea applies there, that when the radioactivity is low, the specific activity is low, that the risk management features and waste isolation features of a hazardous waste landfill can be adequate to not isolate the hazardous waste from the environment, but also the radioactive waste.

It turns out, I understand, that the biggest hazard in the hazardous waste facility, excepting radioactive waste, is to the worker. That is, once it goes into the cell itself, there is not much of a hazard to the environment or to the public, but there are doses associated with exposures of workers to radioactive materials coming into the facility.

MR. LARSON: How old are those, Jim? The reason I ask is that the EDO, under Dr. Paperiello's signature, asked the committee to comment on that if they had any observations. And, you know, it has never been -- neither one of those has been presented to the committee, so I don't know how old they are or what the status is, and we have been asked to say something.

MR. KENNEDY: Yes. Well, both are a couple of years old. I mean they started out as an idea, one rulemaking, the one that allows hazardous waste to go -- slightly hazardous waste to go to a Part 61 facility, that was issued for public comment as a proposed rule on November 19th and that is expected to be issued, actually, as a final rule around the end of this year. Our involvement has been relatively minor in that, as you might imagine.

Now, the other rule is one where, once EPA passed its rule, this is the one that would allow low activity mixed waste to be disposed of in a RCRA facility, once EPA promulgated its rule, or just before that, NRC would also need to promulgate a rule to issue a general license to RCRA hazardous waste facilities that would enable them to accept radioactive waste. And that would be the one where there would be both more NRC staff involvement, because we would have to write a rule allowing for a general license for RCRA hazardous waste landfills, and there would be ACNW involvement, too.

Now, that rule at the moment actually is on hold. NRC and EPA, first off, have some issues on it, including 15 versus 25 millirem per year. There is also some concerns about whether EPA has authority to set standards based on worker protection, because it turns out that the limiting factor is exposure of the workers, and, under law, EPA does not have authority over worker protection. And, so, that needs to be ironed out. We know what the issues are.

EPA, at the moment, actually, is devoting more attention to the high level waste standard that they are developing for 40 CFR 197, and, so, this rule is on the back-burner at the moment, but it is a rule that folks have an interest in, particularly, the industry. It is a better, more efficient way of managing waste and more sensible, risk-informed way of managing low level waste and mixed waste, so that we hope that will come in the future.

Another effort, specific effort that we have underway on the staff is to develop a rule for greater than Class C low level waste storage at nuclear power plant dry storage facilities. Many nuclear power plants at the moment store their small quantity of GTCC waste, it isn't very much, many of them store that waste in their spent fuel pools now. And under our existing regulations, if they get an independent spent fuel storage installation, a dry storage facility, and license it under Part 72, there are no provisions that allow them to store greater than Class C waste.

It turns out that, under Part 72, all they can do is store spent fuel and nothing else. So, when they get rid of their spent fuel pool and try to transfer everything, not just the spent fuel, but the small amount of GTCC, there is no place to put it. Unless they were to get -- they could get a separate NRC license under Part 30 to store byproduct material, which is what the GTCC is. But that doesn't make a whole lot of sense, and what we are doing is streamlining things and allowing for, with this proposed rule, the storage of GTCC, under Part 72, in spent fuel storage installations.

That proposed rule has just -- it is about to go up to the Commission in a Commission paper. Maybe it has gone up as of today, but it is imminent, and it will be going out, after the Commission decides on it as a proposed rule in the near future, we hope. That might be something you would want to look at. I don't know, but I think, normally, don't you often get involved in proposed rules reviews? I leave that to you.

Another activity that we have is to participate in IMPEP reviews. IMPEP is Integrated Materials Performance Evaluation Program. It is our reviews of both NRC regions and Agreement States to ensure that they are carrying out their programs adequately. It is managed out of the Office of State Programs. It is something that largely has to do with Agreement States, because there are many more Agreement States than they are NRC regions.

But they take teams of, typically, four to six people out to either the region or an Agreement State, with NRC staffers from different offices, typically, the Office of State Programs, of course, but, also, our materials licensing folks, division of waste management people, and they always include a member of an Agreement State, too, to go along as a member of the team. And they routinely do those reviews, of course, for materials licensing, and we also do them occasionally for Part 61 disposal facility licensing in the states of Washington, Utah and South Carolina.

We were down in South Carolina, I believe it was last summer. Boby Eid actually participated in that review. I think we were out in Washington last year also, and, Utah, I am not sure when we will be going to Utah, but we will be a part of that review and go out and examine their low level waste disposal program and see how well they are doing.

And, finally, there is just a whole host of miscellaneous things that come up in low level waste disposal. Nuclear power reactor inspections, for example, where they have to classify and package waste under Part 61. We get involved in that. We get involved in guidance interpretation for members of the public and licensees around the country. We work with Congressional Affairs on miscellaneous issues that come up on the Hill and public affairs issues that come up mainly with members of the public, periodically, we get a few of those a week.

Any questions on that part? Do we want to save those for later?

[No response.]

DR. WYMER: Fine. Proceed.

MR. KENNEDY: I don't say a lot, but I think I could talk about this chart for a hour, but I'll try not to.

[Laughter.]

MR. KENNEDY: To me, there is so much here. This is a chart. Now, let me just explain what it is first.

It's a chart of relative specific radioactivity for the different kinds of radioactive waste. Specific radioactivity means curies per cubic meter, or picocuries per gram.

Originally, we had these units down here in terms of curies per cubic meter, which are the units that are in Part 61 for waste classification, and we prepared this slide actually for some Congressional testimony that hasn't happened yet.

But we wanted to simplify it, and rather than put in curies per cubic meter, what we did was, we took the low end of soil and just called that one and put everything else in terms of the low end of soil. In other words, TENORM, for example, the high end of TENORM is technologically enhanced naturally occurring radioactive material; that is naturally occurring radioactive materials that have been in some way altered by man, either moving them or concentrating the radionuclides, or both.

It would, for example, be uranium ore that's removed from the earth and left in the pile.

You can see that's about five times ten to the fourth or about 50,000 times higher than the low end of soil in terms of its specific radioactivity.

CHAIRMAN GARRICK: What soil is that? When you say soil, that's your standard?

MR. KENNEDY: That's standard, run-of-the-mill U.S. soil. We got it from NCRP-50, typically like, oh, one to four picocuries per gram of uranium, plus Thorium 232 and radium and so forth, and their daughters, in that neighborhood.

The absolute numbers are not so important here. They are approximate, first off, because many of these don't have a rigid, firm, top end. TENORM doesn't, low-level waste doesn't. Exempt source material does, and I'll talk more about that.

Uranium mill tailings doesn't have a single number that's at the top or even at the bottom for that matter, but you get the idea.

And what we've done is just calculated from -- a lot of this data came from DOE's integrated database report, last published, I believe, in 1996, which is an excellent overview of radioactive wastes in the U.S., all the sources of it, and radionuclides and concentrations and volumes and so forth.

And what we've done is take that information and just put a range of the relative radioactivity for 11(e)(2) byproduct material, or uranium mill tailings, for low-level waste, for NORM and TENORM. NORM is naturally-occurring, and accelerator-produced radioactive material. TENORM is naturally-occurring material that's been technologically enhanced in some way by man, by humans.

Exempt source material is a provision in the regulation under 40.13 whereby source material less than .05 weight/percent is exempt from regulation by NRC, so that turns out to be .05 percent uranium and/or thorium, and this is spent reactor fuel way up here.

CHAIRMAN GARRICK: I'm wondering if that sends the right message? Because your low-level waste, as you just said, goes up to your -- almost to the bottom of your spent fuel category.

MR. KENNEDY: We've had that pointed out to us. And actually there is a corresponding chart that we've made that can go along with this. We haven't always used it.

But what it shows is that this waste up here -- and, in fact, you can take radionuclides out of Part 61, and what you will find is that the shorter-lived radionuclides are the ones father up like Cobalt-60 and Strontium-90.

And if you look at this chart after 1,000 years or 10,000 years, what you'll find out is that the spent fuel has decayed a couple of orders of magnitude, the high end of low-level waste has virtually disappeared and it's all down in this end now; and down for these other materials, 11(e)(2) byproduct material, NARM and TENORM, and exempt source material, they're principally made up of uranium, thorium, and radium, and so they stay virtually the same.

So, another way to look at this chart is take it after 1,000 or 10,000 years and what you'll see is that this is way down here.

CHAIRMAN GARRICK: Yes, yes. It's just that it seems that there needs to be some sort of benchmark or markers that would give people some measure of the specific activity or something that would indicate whether it's dangerous or not dangerous.

MR. KENNEDY: Yes. Well, I hear what you're saying, and like all of these things, this chart, there is a lot of information here that's pertinent that's not shown because it's two-dimensional.

CHAIRMAN GARRICK: Right. I'm always a little suspect of dimensionalist, non-physical meaning methods of measure.

DR. HORNBERGER: We just plot them on an arithmetic scale and you only see the high level.

CHAIRMAN GARRICK: Right, yes, okay. Well, I appreciate what you're trying to do. It's just that it's a question of whether or not it's a good way -- a good form of risk communication.

MR. KENNEDY: Yes, I understand what you're saying. We've had a number of folks, environmental groups, in particular, come back to us and say, ah, what do you mean, low-level waste? Low-level waste is almost like high-level waste, you know?

CHAIRMAN GARRICK: Yes.

MR. KENNEDY: And so more needs to be said about that.

MR. LEVENSON: Can you show distributions with activity level? That would help.

MR. KENNEDY: Yes. Like I said, I could go on all day with this, but another thing that's not shown on this is volumes. I think that's really instructive.

You know about spent fuel volumes. All of that will go to Yucca Mountain, and there's not much greater than Class C waste, which is right up here, and maybe comprises just the tip of that bar there.

There's 2,000 cubic meters that will be generated in the next -- both in storage now and that will be generated by nuclear power reactors over the next 30 years -- 2,000 cubic meters. That's not very much.

NARM, TENORM, there's, I understand from a recent EPA report, some 1.6 billion tons of TENORM in the U.S. -- 1.6 billion tons. I don't know about the quantities for that. Low-level waste, I don't know the precise quantities of that down here, but we do know it's millions and millions of cubic feet, just in the commercial programs when you take the SDMP sites and decommissioning of nuclear power reactors, for example, and contaminated soil and so forth.

So, you know, compare 2,000 cubic meters, which is 90,000 cubic feet or so, and millions of cubic feet down here, so another dimension of this, if we had a third dimension, would show volumes very, very large down here on the orders of magnitude difference between what's down at this end and what's up here.

Another thing that's important is that these materials have in some cases, anyway -- are required by regulation and law to be disposed of in different ways, even when the hazard is similar or the same.

For example, 11(e)(2) byproduct material or uranium mill tailings, must go to a licensed 11(e)(2) mill tailings impoundment under 10 CFR Part 40, Appendix A.

Low-level waste, on the other hand -- I'll talk more about this end of low-level waste, but in general, it's required to go to a Part 61 disposal facility, and we'll talk about some exceptions to that.

TENORM, well, TENORM is regulated not by -- it's regulated by states. They regulate it in different ways. There are some states that don't regulate it at all.

Some of it or much of it is allowed to go to RCRA Subtitle C facilities. In the state of Michigan, anyway, if not a few other states, it's also allowed in some cases to go to conventional landfills.

And some of the TENORM, at the high end in particular -- this is really hot here, by the way. This is like 400,000 picocuries per gram at the high end.

It's not required to go any particular place, but it's often sent to a low-level waste disposal site because it's so hot and so hazardous.

Exempt source material is simply exempt under our regulations right now, and that typically either goes to a Part 61 facility, or more and more these days it's going to RCRA hazardous waste facilities. Of course, you know about spent fuel.

Any questions on that, because I'm going to flip to the next page?

[No response.]

MR. KENNEDY: And what we find being the focus of low-level waste these days is not Part 61 facility developed. We talked about how the state and compact efforts are stalled. There are some private initiatives out there, which are ongoing and which we support.

But what we also find in a much larger respect is folks encouraging us generators and even the Commission taking some initiative in this, too, of looking at alternatives for better managing -- let's see if I can do this right -- better managing the low end of low-level waste.

I was trying to get that back up there, but -- yes. It doesn't seem to be working.

Let me start up with rubbelization. It's such a large file it takes a long time to do it. But we find a lot of focus, because of the large volume and high cost of generators coming to us and we're taking some initiatives on our own, of addressing this end, this waste down here.

Part 61 facilities, in general, are designed to handle the higher activity, B/C waste, and higher end of Class A, and are really not needed in all cases for this low end.

And yet this is where there's a lot of waste. The cost is high to get rid of it, the hazard is not very high, and so what we see is an increased emphasis on the low end.

And one thing that just jumps out to me from this chart is that why can't some low-level waste go to a mill tailings impoundment when everything else is the same, and why can't some go to where TENORM goes, when everything else is the same? So, we'll talk about how we're answering that question.

Let me continue with that point before I come back to entombment. But one of the ways that that is manifesting itself is this concept of rubbelization whereby nuclear power reactors would clean up buildings and leave some residual radioactivity on buildings, but dispose of the rubbelized concrete and building debris and so forth in a building onsite in the foundation of a building, and cover it over with soil.

And it's low specific activity material. It's material that could be called low-level waste and might, in the old days, be sent to a low-level waste site. But with that approach, it becomes simply residual radioactivity from decommissioning, and can be left onsite because even with that material there, they would be required to meet the 25 millirem per year dose limit for reactor decommissioning.

Another takeoff on that earlier chart and expanding the disposal options is the use of uranium mill tailings impoundments for disposal of similar low-level waste, that is, waste that has the same radionuclides, uranium, thorium, and their daughters, and disposing of those in uranium mill tailings impoundments.

Now, the Staff prepared a Commission paper last year, SECY 99-012. It was prepared in response to some National Mining Association initiatives, a white paper that they prepared that proposed and argued for expanded use of mill tailings impoundment for low-level waste disposal.

And so the Commission has addressed that in the Commission paper. That's been before the Commission about a little bit more than a year now. And the Commission, we think, is going to be issuing a decision on that shortly.

The decision will be, first, whether to incorporate into a new Part 41, provisions that would allow for that, and to specify which low-level waste and under what conditions it could be allowed to go to a uranium mill tailings impoundment.

Let me come back up to entombment. That is a little bit different in the sense that it doesn't involve particularly the low end material but involves the high end material and the idea is to take lower level waste from a nuclear power reactor, entomb it into the containment building -- that is, seal it into the containment building, to monitor the containment building for 100 to 300 years and then to allow for unrestricted release after that period of time.

What it does is it allows for onsite disposal, of course, but it allows for leaving a lot of the relatively short-lived low level waste in the building itself and letting it decay away after 100 to 300 years and then releasing the site, rather than send it to a Part 61 disposal facility. That is something that is being explored right now. We have had a couple of workshops on that. There is a Commission paper also about to go up to the Commission describing the results of a workshop that we had last December, and we expect to be moving ahead with that.

The step that we need to take to make that more real is to promulgate a rulemaking allowing for that to happen. The rulemaking is probably somewhat far off, but we are moving step by step on that effort. That would also, by the way, have a huge impact on the amount of low level waste that is generated from decommissioning of a nuclear power reactor because most of it would be left onsite.

Another alternative in a somewhat different sense are short isolation facilities. A short isolation facility, I think most of you are familiar with that, right, Howard? -- is a new concept that is not disposal but it is an option for managing low level waste whereby the waste would be placed into a facility that looks like a modern, highly engineered facility but it would be placed there without any commitment to leave it there forever.

In other words, it might be left there or it might not be. The options for how it gets handled into the near future or just in future even are left open.

One of the ideas behind that is that the local community would have a chance to gain confidence in the performance of the facility if it were going there without a final decision and would be there forever and --

CHAIRMAN GARRICK: What of the licensing, what are the alternatives for the duration of the license?

MR. KENNEDY: Well, that is the $64,000 Question, and that is the one that we haven't given an answer to. The proponents of a short isolation have come up with a licensing strategy whereby a license would be issued for storage in renewable terms of, say, 10 to 30 years, and that after each term one would simply decide at that point -- first off, the operators would decide whether they were going to keep the waste there and the licensing organization would decide whether it could be renewed for another 10 to 30 year term.

CHAIRMAN GARRICK: So it is not unlike the way EPA has certified WIPP --

MR. KENNEDY: Yes.

CHAIRMAN GARRICK: -- where they have five year recertifications.

MR. KENNEDY: Exactly.

CHAIRMAN GARRICK: Yes.

MR. KENNEDY: In fact, conceptually in some ways, in important ways I would argue, it resembles a RCRA permitting scheme and even risk management approach in that the primary means of managing risk with a short isolation is through institutional controls and the commitment to monitor it and survey it and make sure it is working right.

One of the advantages that the proponents argue is that you don't need a good site. You can put it anywhere, and you don't need to do a performance assessment and modeling for 10,000 years, which they argue is difficult and creates difficulties in licensing, but that one can simply issue a storage license for 10 years or 30 years and that is no big deal.

It has some advantages. The Commission has not been very much involved in that. We are certainly aware of it. Chairman Jackson has written a few letters on it. We have identified some concerns like the main one being under what provisions of our regulations or in Agreement State regulations should such a facility be licensed -- that is, the storage regulations or Part 61 and, you know, just what is it? Is it storage or is it disposal? The Commission has not spoken on that.

We are simply waiting to have a proposal put before us, which we haven't had yet.

The state of Texas has an application from Envirocare of Texas for one of these facilities. They had rejected the application or put it on hold. I understand that as of last month they have taken it off hold and I think they got some eight pages of review comments on it right now.

We have been talking to Texas. We have asked Texas to keep us informed of what they are doing so that the Commission is informed and agrees with whatever licensing concepts that they come up with.

Clearance of solid materials -- that is the clearance rulemaking, an extension of what we were talking about earlier, and that is allowing some of the low end, low level waste go to other types of facilities. If you carry that thinking a step further, it is logical to include the release of solid materials at some very low levels for unrestricted use and of course that is what the clearance effort is all about. I am sure you are all aware of that.

What that is basically is that at some level near background radiation, near the level of radioactivity that is in soil it is okay and it is safe to release licensed radioactive material for unrestricted use.

Another item that we are working on right now is low and source material rulemaking and one of the bars on that earlier chart was exempt quantities of source material, which is .05 percent uranium or thorium in our regulations that is exempt from regulation.

In SECY 99-259 the Staff proposed that we add a provision to that rulemaking to better define the conditions under which it could be released for unrestricted use and for disposal. It turns out that in some cases some fairly conservative cases of unimportant quantities of source material like a worker handling zircon flour for 2000 hours a year of flour material that he inhales a fair amount of, you can get doses up over a rem per year potentially and so we are doing a rulemaking that addresses some of those cases and it looks like the proposed rule will have in it a 100 millirem per year maximum dose to anyone including a worker at a facility handling these quantities of source material.

That rulemaking is just beginning. I think we are supposed to have a proposed rule in place or out on the street -- we are up to the Commission rather in September of this year.

Finally, I will mention something different here, the FUSRAP program or Formerly Utilized Site Remedial Action Program. This is a program that is currently being implemented by the Army Corps of Engineers. It involves Manhattan Engineer District sites around the country from the 1940s and 1950s that have radioactive contamination. Much of it is 11(e)(2) byproduct material that is the residuals from the extraction of uranium.

That program was transferred to the Army Corps from the Department of Energy in 1997 and the Army Corps has been quite vigorous in looking at alternatives to disposal from conventional disposal facilities like 11(e)(2) disposal cells in low level waste sites and they have promoted I would say and looked at carefully and are using RCRA Subtitle C facilities around the country for disposing of this kind of waste and kind of the basic principle is that if it is good enough for TENORM or it's good enough for other low end radioactivity materials, it is okay for the FUSRAP material, which also is down at the low end.

Mostly it is 11(e)(2) byproduct material mixed with soil so it is not even as big a range as what we are showing up on that chart.

We don't regulate FUSRAP. The Army Corps is self-regulating under CERCLA for their onsite cleanups but there has been a lot of interest in it. It was on the front page of the Washington Post about two months ago I think.

We get a fair number of requests from people on the outside concerning the FUSRAP program, from states sometimes. We have a couple of 2.206 petitions, one from the Snake River Alliance out in Idaho concerning a RCRA Subtitle C facility out there that is accepting some of this waste and the other from Envirocare of Utah, both asking us to regulate the disposal of that material. They believe it needs to be done and those were submitted about three months ago I think and we are processing those petitions right now.

One thing I didn't mention today is research. There is no discrete Low Level Waste Program or research program for low level waste but we do do research upstairs under a program that is called Radionuclide Transport in the Environment that pertains not just to decommissioning and high level waste but also potentially to low level waste disposal facilities, and we are doing work for example on degradation of concrete which applies to most modern disposal facilities and potentially to our short isolation facilities.

We are doing work on absorption of radionuclides and monitoring and transport of waste in the ground and the Vadose zone for example, so there is some research being done by the Office of Research, although it doesn't fall under the name of low level waste per se.

Here is a summary of what -- wrong way -- whoops. That is the first time I have used Corel Presentation, so bear with me. Here's the summary of Tom and I, both Tom and I talked about today.

First, I think it is fairly clear. It states some compacts haven't been able to develop new facilities. We do have disposal capacity available today but the future isn't certain. Barnwell is going to be closing down over the next eight years. It is not clear when or whether Envirocare will get their BC application approved.

We continue to implement our Low Level Waste Program as directed by the Commission in general in 1997. We continue to support other in-house initiatives and I would say spend even more time on this. That involves alternatives to conventional management and disposal of low level wastes, such as entombment, rubbelization, low end source material, use of mill tailings, empoundments and so forth, and we are also supporting outside efforts to examine alternatives such as the NAS study for low level radioactive waste disposal in the country.

DR. WYMER: Thank you very much for a very thorough and informative presentation. We appreciate it.

Are there any questions?

CHAIRMAN GARRICK: I just have one. Approximately four years ago this committee, which was made up of mostly different people than now exist, sent a letter to the Chairman describing what ACNW thought would constitute a basic or an adequate Low Level Waste Program for the NRC.

The overarching message of that letter was that the NRC should maintain a national cognizance of the low level waste business.

Do you in your branch have information or do the type of analysis that would really respond to a question that might come from Congress or somewhere that says something about the urgency or lack of urgency of low level waste disposal? Do we really have a good handle on where we are, given that we have had so many failures, if you wish, at the state compact level?

Two or three of the items that we had in our letter was to maintain an evaluation capability, to maintain some of the elements of a research perspective, and to be in a position to fill gaps as we learn about them, as the states get experience.

So my real question is should we be worrying about this? Should this committee be pushing the Commission to be more active or to look for alternatives or what have you? I am basically an analyst so what I would say is needed is an analysis of the inventory and what capacity exists and some sort of a time-wise assessment of when we are getting in trouble.

Obviously you can probably always have the capacity if you are willing to pay the price, but I am thinking in terms of a cost benefit being a part of that equation as well.

MR. KENNEDY: I would think we would all agree that that kind of study would be useful, that most people agree if not everyone that even though we have disposal capacity today the future is uncertain, that anything could happen, and particularly with decommissioning of nuclear power plants coming on in the next, who knows? -- I mean some of it is ongoing now and certainly there will be more as time goes on.

My sense is when the Commission considered this back in 1996 and 1997 with respect to the strategic assessment effort, they decided to not get into some of these bigger issues about what might we do to better ensure future disposal capacity. You know, we put that option before them and they intentionally did not choose it, and my personal sense is, and I think this is an Agency sense too, is that that is something that would be difficult to do, to study the future and do all the analysis and so forth.

I think where we are on it is this letter supporting the National Academy proposed study that should be going out any day now where we make a commitment to provide some funds and that is the exact thing that they are going to do. They are going to look at the waste stream today, what it might be in the future, what the disposal needs might be in the future, what the likelihood is of having new disposal capacity to handle that waste, and we feel and I feel that they are far better equipped to look at that and study it and make recommendations than we are.

CHAIRMAN GARRICK: Do you have a schedule for that?

MR. KENNEDY: No, we don't. There are -- they haven't begun it yet. They are looking for funding. They need to get a certain level of funding before they can begin it.

CHAIRMAN GARRICK: The problem with the Academy, and I am involved with several of those types of studies, is that it is usually a three-year effort.

MR. KENNEDY: Yes.

CHAIRMAN GARRICK: Before you get results.

MR. KENNEDY: Right.

CHAIRMAN GARRICK: Okay --

DR. HORNBERGER: Sometimes they are more timely than that.

CHAIRMAN GARRICK: Yes.

DR. HORNBERGER: I have a question, sort of a two-part question.

You have mentioned research. I am glad you did mention that.

The two parts of the question are, first, can you tell me how you use the results that are produced by research, how they feed into low level in the more general sense, the more expansive sense that you have used it today.

Second of all, how do you have input that might shape the priorities for the Office of Research?

MR. KENNEDY: I'm not the best person to answer that. I think one of the -- the Office of Research and the fellows up there who are working on projects that potentially involve low-level waste in the future -- Tom Nicholson, Ed O'Donnell, Jake Phillip and so forth, Linda Kovach -- they tend to have much more interaction with folks in the performance assessment section, Mark Thaggard, Bobby Eid and so forth, than they do with me. I'm more a project manager type.

I'll be honest, I think we could do more with the information that they are generating in terms of being aware of what it is and making sure that it's being utilized as best as possible by the technical staff.

I think another place where we could do better at that is making sure that that information gets out to the states and other people who potentially have an interest in it, because as you know, the states are the ones who are doing the licensing of these facilities right now -- that is, Barnwell, Washington and Utah -- and they need to be and I think can be better plugged into what we're doing in research. We right here could do a better job in making that connection happen than we have in the past.

MR. ESSIG: I would offer that we'll try to speak to that a little bit more tomorrow when John Graves is here, see if we can --

MR. RANDALL: May I add something? Years ago when there was a program dedicated to low-level waste research, we had an outreach meeting with several state parties and some that aren't even involved anymore, like North Carolina, and I think we dropped the ball because we didn't follow up on it. We had a staff member designated to keep the states involved through a newsletter and she changed jobs and we didn't get anybody else to pick up on it.

I think that Jim's idea is good, that we should -- that the Research Office should be doing something to support the state programs, state low-level waste programs. We're really not doing it.

MR. KENNEDY: Tim, did you have something you wanted to add?

MR. HARRIS: Yes. One thing that we were doing was attending -- DOE had a technical TCC, technical coordinating committee, which was basically a technical meeting of states developing things, and that was really an interchange. Ed O'Donnell and I used to attend those, and that would be an information transfer.

They are no longer conduct that, I don't believe, so --

MR. KENNEDY: That has been eliminated.

MR. HARRIS: That activity has ceased. But that was one way that we did transfer that information to the states.

DR. HORNBERGER: Is there any comment on the second part of my question as to the input you have, or did you want to put that off until we talk to John Greeves?

MR. ESSIG: I think I would just as soon put it off until we talk with John and we'll give you a better answer than we're able to give you today.

DR. CAMPBELL: I think part of your question, I think can answer since I've been a team leader up in Research for the last six months for the Rad Transport and Decommissioning Group.

First of all, about 75 percent of the work up there is in response to user needs from NMSS. Virtually all of that is decommissioning type of work, work on DND, work on RESRAD. Some of the work that Tom has been doing is user need work. There are a few other projects. But most of the work done up there is in response to a need from Division of Waste Management, and certainly Research, with or without me up there, is going to be responsive to any user need requests that come from the division from the performance assessment and low level waste branch.

In terms of how that's used, you know, that's usually in response to very specific needs that they have for modeling decommissioning sites, dose modeling the decommissioning sites and materials. Linda's work on the slags was in response to -- we had no information on what those slags were, what the mineralogy was, what their potential for leeching was. That's where Linda's work fit in.

The input to Research, there's a lot of interaction at the branch chief level. Cherly Trottier attends branch chief meetings John Greeves holds on a regular basis. I've been to those meetings.

So there is an ongoing dialogue, if you will, and interactions. In addition, the Ops plans, which have very specific products and targets, are coordinated between the two offices, if you will, and the Division of Waste Management has on its Ops plan RES projects and specific products out of those projects, and our Ops plan requires that the people in the group make sure their products get done in a reasonable timeframe, and if there's a missing of a target date or something like that, then that's done.

So there is a lot of interaction going on and coordination.

DR. HORNBERGER: Just one other comment.

We've heard pretty much what you've said, Andy, so it's not as if we're operating in full ignorance of those things. I'm just curious to ask the question of people let's say in the trenches doing the work to see whether or not, in fact, the transfer is as efficient as those in Research and elsewhere would like it to be. That's just a curiosity question. I was curious as to your views.

DR. WYMER: I want to follow up just a little bit on one comment. It had to do with cost and cost benefit. As you are more aware than I am, the amount of money at stake for the industry is enormous, and the decision such as rubblization and the clearance rule and in general the high volumes of low-level waste going to expensive storage facilities.

So my question to you is, can you go beyond the statement of saying people have got to meet the 25 millirem per year standard, can you go beyond that and say how cost figures into what you do and the kind of recommendations and decisions you make?

MR. KENNEDY: Well --

MR. ESSIG: I could attempt to answer that. Of course, the licensee has to meet the 25, but then there's an ALARA provision and that's where cost considerations come.

DR. WYMER: That's where you've got your flexibility.

MR. ESSIG: That's where the tradeoffs are made.

DR. WYMER: So how do you handle that?

MR. ESSIG: That's unfortunately an area that we aren't involved in. It's our Decommissioning Branch. We could again offer to provide an answer tomorrow when John is here.

DR. WYMER: It does become low-level waste.

MR. ESSIG: Yes.

DR. WYMER: Okay. Let's wait.

MR. ESSIG: It's really a cost consideration that's being made by the licensee that's undergoing the decommissioning, and that aspect of it is reviewed by our Decommissioning Branch.

DR. WYMER: We'll hold that one until tomorrow, too, then.

MR. ESSIG: Okay.

MR. KENNEDY: Can I add one thing on that? Or actually, two things. I can't resist.

One of them is, on the 25 millirem for year in the decommissioning rule, cost was looked at in the generic environmental impact statement for that rulemaking. That was one of the considerations.

The other is, of course you have a point. I mean, to illustrate that, we just look at TENORM, for example. Much TENORM isn't being managed or it's going to other kinds of facilities, in large part because there's so much of it and the cost is so enormous to dispose of it that folks are allowing it to basically be disposed of with potentially higher dose levels than 25 millirem per year.

DR. WYMER: That's in the nature of the kind of thing I was getting at, yes.

MR. KENNEDY: Yes.

DR. WYMER: Okay.

MR. KENNEDY: And you probably know that under CERCLA, cost is a consideration that's allowed to be considered, and the risk range for CERCLA cleanups, according to the recent NAS report, goes all the way down to ten to the minus two lifetime cancer risk, which equates to about 300 millirem per year, and that's because cost is a factor that's allowed to be considered in CERCLA cleanups.

DR. WYMER: You and I should sometime have a more thorough discussion of just that aspect.

MR. KENNEDY: Yes. Exactly.

MR. LEVENSON: Can you retrieve slide 12? That's your bar graph. You can expect to be challenged when you come here.

MR. KENNEDY: I don't think it will load up.

[Laughter.]

MR. LEVENSON: Well, okay --

MR. KENNEDY: No, I'm trying, actually. It's about two megabytes. That's why --

MR. LEVENSON: Oh. Yes. Okay.

MR. KENNEDY: Here it is.

MR. LEVENSON: Let me ask you a question. Congress chose to define a whole category or radioactive materials as non-radioactive if they came from sources like coal plants. Are they listed in your bar graph under like exempt, or are they just not there at all?

MR. KENNEDY: They would be TENORM, actually.

MR. LEVENSON: So all of the coal-plant fly ash and everything is in the TENORM category?

MR. KENNEDY: Yes. Yes. And actually, your probably aware, it sounds like, that EPA just exempted everything in coal ash from being regulated, not just the radioactive materials, but also the hazardous constituents.

MR. LEVENSON: Yes. The mercury and everything.

MR. KENNEDY: Right. But that's part of the TENORM. Usually, the coal ash is pretty low in radioactivity, like ten picocuries per gram, I think, but in some cases, it's as high as 3,000 picocuries per gram.

MR. LEVENSON: Yes. Fly ash can be quite high.

MR. KENNEDY: Yes.

MR. LEVENSON: The second thing which your chart doesn't show is volume.

MR. KENNEDY: Yes.

MR. LEVENSON: Of the TENORM, is the coal residue a major -- I don't want any numbers -- is it a major percentage of the total TENORM?

MR. KENNEDY: You know, I just don't know. I could find out and get back to you, because I do have figures on it.

MR. LEVENSON: I'm curious. Okay. Thank you.

MR. KENNEDY: There's a lot of TENORM out there -- phosphate fertilizer residue, --

MR. LEVENSON: Tin mill smelting.

MR. KENNEDY: Tin mill smelting, yes. Radium pipe scale, uranium mining overburden.

DR. WYMER: There's a lot of don't ask, don't tell stuff.

MR. KENNEDY: Yes.

MR. LEVENSON: One that usually gets overlooked -- people are aware of thorium and uranium. People don't necessarily know that tin is normally accompanied by uranium and thorium, and so the slag --

MR. KENNEDY: Yes. Yes. We have a couple of NRC licensees that were simply metal processors who got above

.05 percent source material and had to get an NRC license because of the concentration of uranium and thorium.

MR. LEVENSON: Thank you.

DR. WYMER: Anybody else. The staff?

DR. CAMPBELL: I have a couple of questions.

In California, this advisory committee said they were talking about dividing the waste stream by hazard, and use half-life. Is that the only criteria they use? Because a lot of the low-level waste with a long half-life doesn't necessarily come out of power reactors. A lot of it comes from industrial producers, label product compound products and the biotech industry and so on. Carbon 14, uranium, thorium and things like that show up in low-level waste as Class A waste. Did they make some further distinctions or was it just power plants versus everybody else?

MR. KENNEDY: I believe -- I haven't read the report that carefully, but I believe it's mainly based on half-life or what they call hazardous life. There are a few exceptions, but in general, it seems to be geared toward separating out the nuclear power plant waste from everything else and doing that as effectively and as best they can.

DR. CAMPBELL: Okay. On the -- and I don't know what page it was, there was a -- said the Commission rejected a larger program of staff efforts to actively promote new site development. We always steered away from that concept. We were promoting regulatory oversight, but I didn't think there was ever any effort to promote site development on the NRC's --

MR. KENNEDY: That was one of the options we put before the Commission as part of strategic assessment, was to take that role of promoting new site development, and the Commission explicitly rejected that, said don't do it.

DR. CAMPBELL: The only other question is, do the assured isolation facilities provide for a decommissioning fund? I mean, obviously the radionuclides are there whether you call it storage, whether you call it assured isolation or you call it low-level waste disposal, at the end of some period of time, you've still got the same stuff there. Do they then provide a fund for decommissioning at the end of their storage lifetime?

MR. KENNEDY: Yes, they do, and the idea is -- assured isolation by definition has as one of its future options the off-site disposal of low-level waste, and so they would have to decommission the facility, they would also have to provide funds to dispose of whatever residual radioactive waste there might be just from the low-level waste that was put in there.

Now, that's a big, important question because if you do the numbers, if you assume that after ten years, whatever low-level waste is left needs to be disposed of at

Barnwell at $500 a cubic foot, that facility is not going to be economical just by inspection.

On the other hand, the assumptions I've seen them make are that there's about $50,000 set aside at the beginning and that waste would not be removed for at least 100 years, and you get so much growth in the $50,000 fund that there is enough money at the end of 100 years to get rid of the remaining waste and to decommission the facility because it appreciates in value so much.

DR. CAMPBELL: Does it require a change in NRC policy that preferred disposal over storage?

MR. KENNEDY: In effect, it does. That's one of the big questions, right. Right.

DR. WYMER: Are there any other questions from anybody?

[No response.]

DR. WYMER: If not, well, thank you very much. Again, it was very a very informative presentation. We appreciate it.

MR. KENNEDY: Thank you.

CHAIRMAN GARRICK: All right. Our plan is now to -- we'll take our break, and then we're going to come back and discuss reports. Most of that time is going to be taken in the members working at their word processors and actually writing reports and letters. We will reconvene for a few minutes to consider some guidance on that, and also the sufficiency letter that we were contemplating sending to the EDO, but most of the time is going to be taken in our respective offices developing drafts.

So unless there's comments, questions, we'll adjourn.

[Whereupon, at 2:54 p.m., the recorded portion of the meeting was concluded.]

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

NAME OF PROCEEDING: 119TH ADVISORY COMMITTEE ON NUCLER WASTE (ACNW)

CASE NO:

PLACE OF PROCEEDING: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Jon Hundley
Official Reporter
Ann Riley & Associates, Ltd.

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

DOE's Repository Safety Strategy

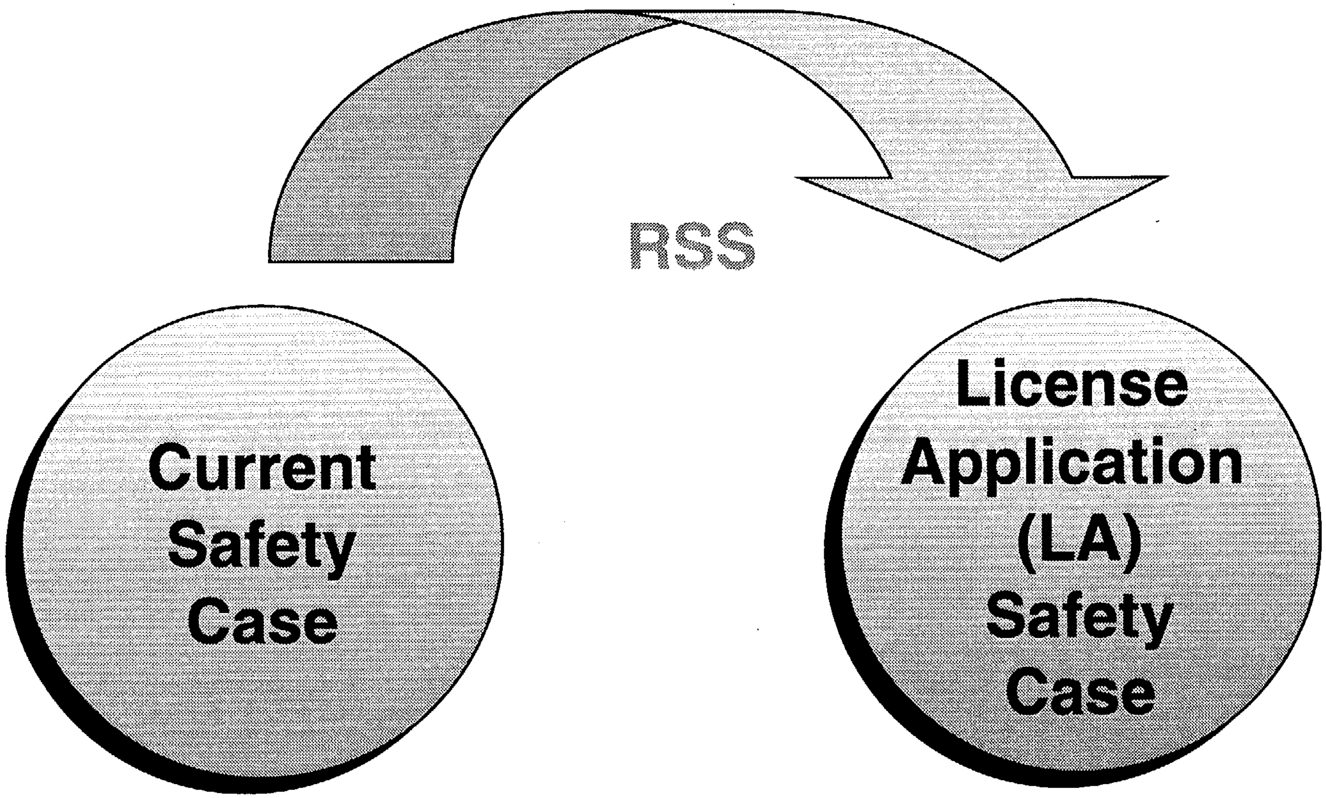
Presented to:
Advisory Committee on Nuclear Waste

Presented by:
Jack Bailey
Director, Regulatory and Licensing
Civilian Radioactive Waste Management System
Management and Operating Contractor

June 14, 2000

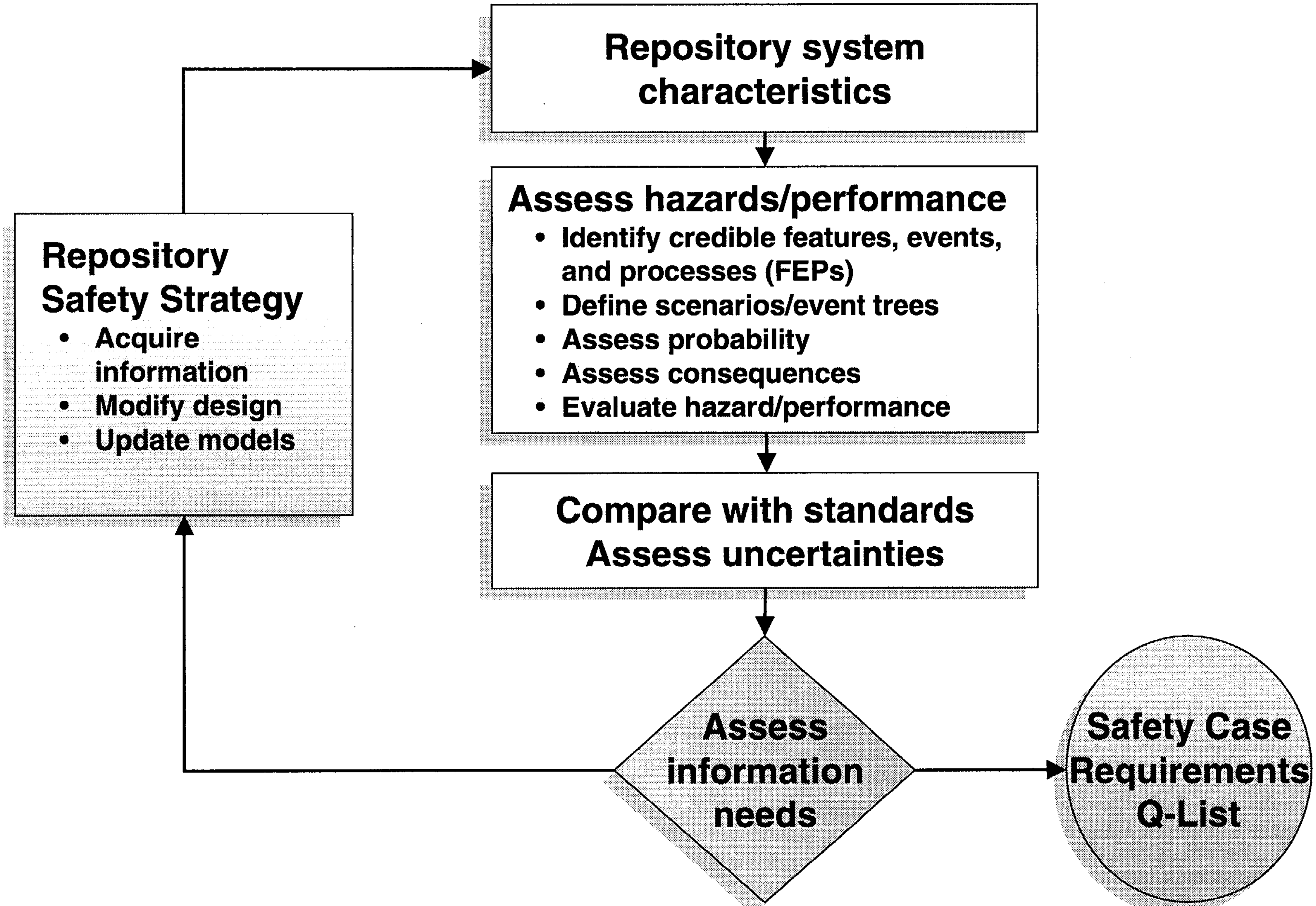
YUCCA MOUNTAIN PROJECT

Repository Safety Strategy (RSS) is a Plan



This plan is determined by management after technical input

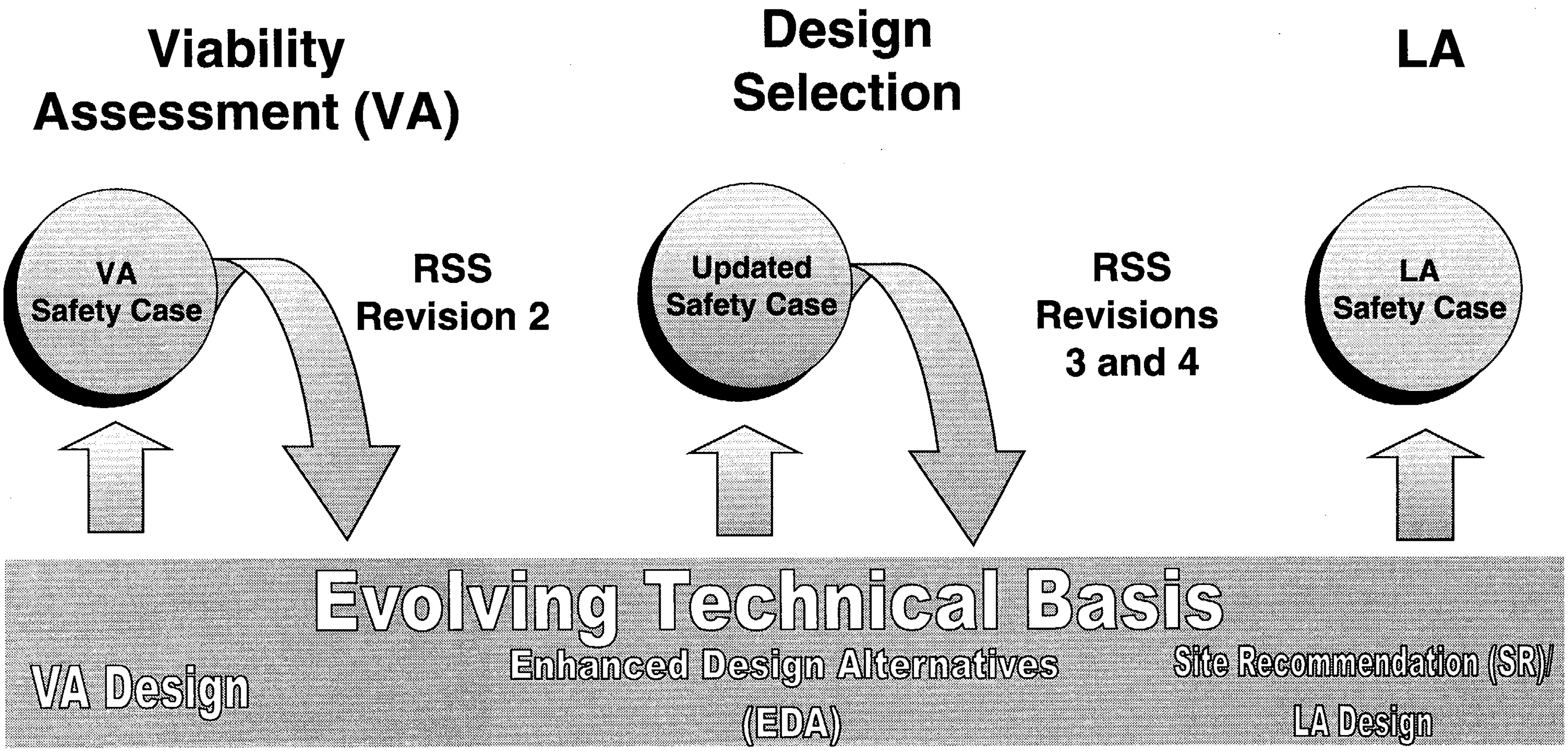
Iterative Nature of the RSS



Target for the RSS

- Adequate understanding--identification of principal factors determining safety
- Performance assessment (PA)
- Measures to increase confidence in safety--measures to address residual uncertainty and other potential vulnerabilities

Revising the RSS

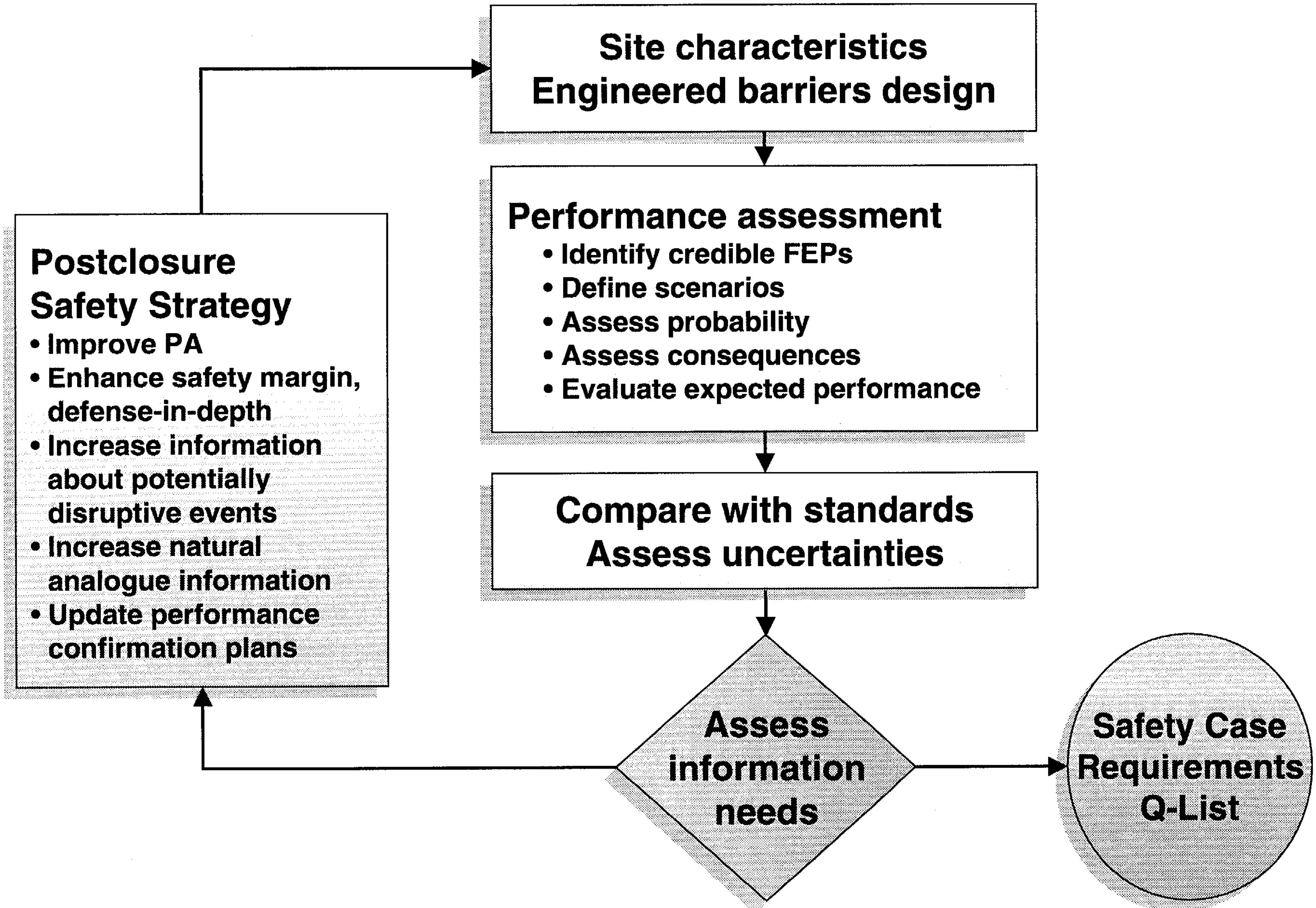


Elements of the Safety Case

- **Postclosure Safety Case**
  - Total system performance assessment (TSPA)
  - Safety margin and defense-in-depth
  - Analysis of potentially disruptive events
  - Insights from natural analogues
  - Performance confirmation

- **Preclosure Safety Case**
  - Integrated safety analysis
  - Safety margin and defense-in-depth
  - Analysis of design basis events
  - Industry precedent and experience
  - Technical specifications and surveillance

Application to Postclosure Safety



Revision 2 of the RSS (VA)

- **Principal factors**
  - Nominal case factors involve all that might play a role (a drop of water moving down through system)
  - No consideration of disruptive events
- **Performance assessment**
  - VA design
  - VA models
- **Measures to increase confidence in postclosure safety**
  - Plans to consider safety margins and defense-in-depth and other elements of the safety case

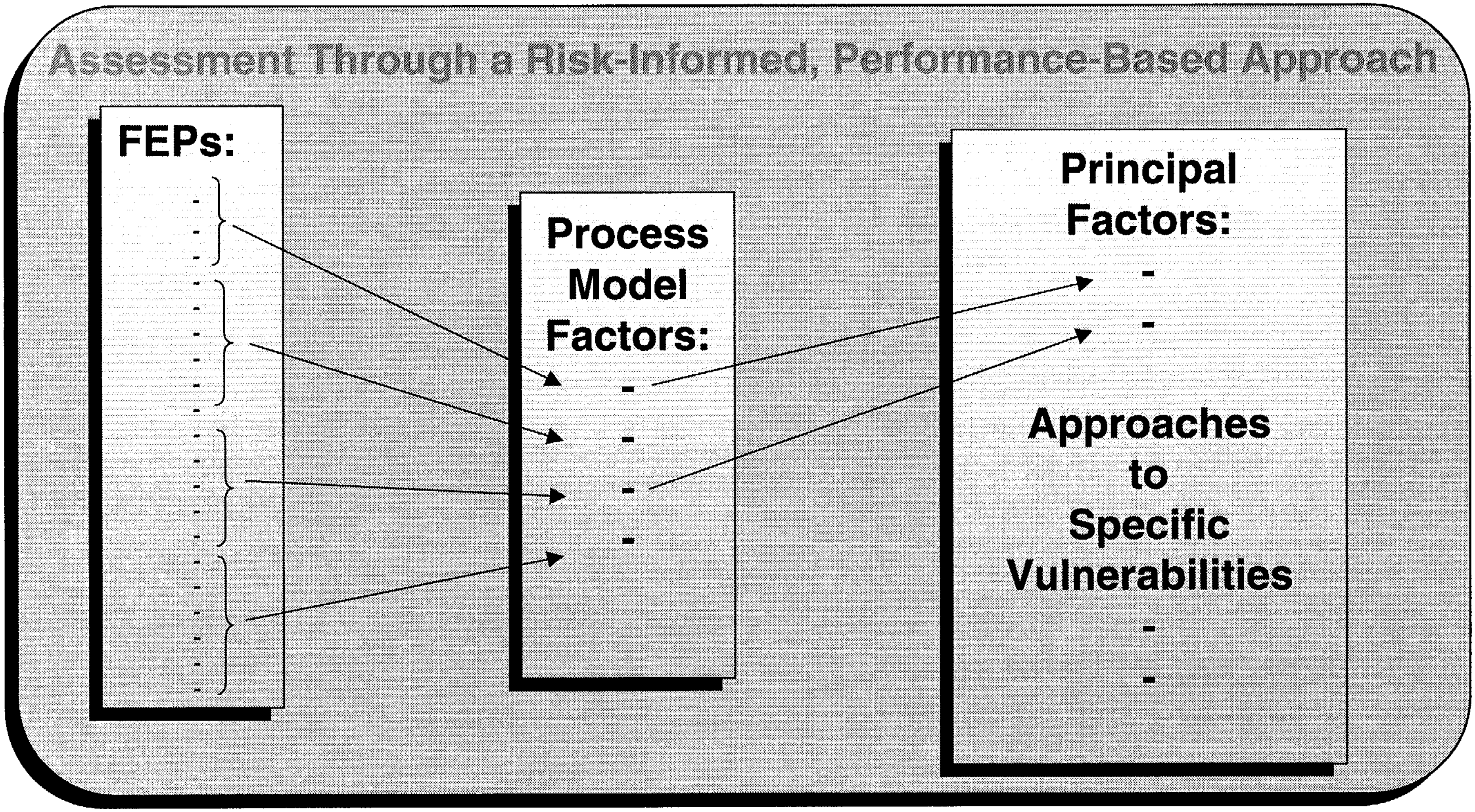
Revision 3 of the RSS

- Principal factors
  - Subjective judgments about factors expected to be most important to performance
  - Judgments supported by "barrier neutralization" analyses
  - No consideration of disruptive events
- Performance assessment
  - Enhanced Design Alternative (EDA) II design
  - VA models for natural system
- Measures to increase confidence in postclosure safety
  - Preliminary consideration of safety margins and defense-in-depth
  - Revision 0 of Performance Confirmation Plan

Revision 4 of the RSS

- Principal factors
  - Developed following a risk-informed, performance-based approach
  - First full evaluation of FEPs
- Performance assessment
  - Updated models fully documented in Process Model Reports (PMRs) and Analysis Model Reports (AMRs)
  - Analyses address range of uncertainties
  - TSPA includes both nominal and igneous activity scenarios
- Measures to increase confidence in postclosure safety
  - Full evaluation of safety margins and defense-in-depth
  - Revision 1 of Performance Confirmation Plan

Approach for Revision 4



Example of FEPs Evaluation

Table B-7. FEPs Considered for Waste Package Degradation Model

PMR	FEP Number	FEP Title	Process Model Factor
Waste Package	2.1.03.01.00	Corrosion of waste containers	Waste Package Degradation and Performance
	2.1.03.02.00	Stress corrosion cracking of waste containers	
	2.1.03.03.00	Pitting of waste containers	
	2.1.03.05.00	Microbially-mediated corrosion of waste container	
	2.1.03.11.00	Container form	
	2.1.03.12.00	Container failure (long-term)	
	2.1.10.01.00	Biological activity in waste and Engineered Barrier System (EBS)	
	2.1.11.06.00	Thermal sensitization of waste containers increases fragility	
	2.1.06.06.00	Effects and degradation of drip shield (general corrosion, localized corrosion, microbial effects)	Drip Shield Degradation and Performance
	1.2.02.03.00	Fault movement shears waste container	Excluded from TSPA on the Basis of Probability and/or Consequence
	1.2.03.02.00	Seismic vibration causes container failure (effects on either waste package or drip shield excluded by design)	
	2.1.03.04.00	Hydride cracking of waste containers	
	2.1.03.06.00	Internal corrosion of waste container	
	2.1.03.07.00	Mechanical impact on waste container (effects of rockfall on drip shield or on waste package—even if drip shield is not present—excluded by design)	
	2.1.03.08.00	Juvenile and early failure of waste containers (initial defects of waste packages or drip shields sufficient to result in juvenile failure excluded)	
	2.1.03.09.00	Copper corrosion	
	2.1.03.10.00	Container healing	
	2.1.06.07.00	Effects at material interfaces	
	2.1.07.01.00	Rockfall (large block)	
	2.1.07.05.00	Creeping of metallic materials in the EBS	
	2.1.09.03.00	Volume increase of corrosion products	
	2.1.09.09.00	Electrochemical effects (electrophoresis, galvanic coupling) in waste and EBS	
	2.1.11.05.00	Differing thermal expansion of repository components	
	2.1.12.03.00	Gas generation (hydrogen) from metal corrosion	
	2.1.13.01.00	Radiolysis	

Resulting Set of Process Model Factors

- **All credible factors considered for nominal scenario**
  - Flow [climate, infiltration, unsaturated zone (UZ) flow, seepage]
  - Thermal effects on UZ flow and seepage
  - Environments (moisture, chemistry, temperature)
  - Drip shield, waste package performance
  - Waste form (cladding, waste form degradation)
  - Concentrations (dissolved and colloid-associated)
  - Engineered barrier system (EBS) radionuclide transport
  - Radionuclide transport in UZ and saturated zone (SZ)
  - Biosphere dose conversion factors

Resulting Set of Process Model Factors
(Continued)

- **Igneous activity scenario factors**
  - Probability of igneous activity
  - Magma intrusion characteristics
  - Response of repository to magma intrusion
  - UZ flow contacting waste
  - Concentrations (dissolved and colloid-associated)
  - Radionuclide transport in UZ and SZ
  - Atmospheric radionuclide transport
  - Biosphere dose conversion factors

Identifying the Principal Factors

- In the risk-informed, performance-based approach, TSPA analyses are the bases for judgments of principal factors
- Analyses include sensitivity studies and barrier importance analyses
- Approach changes focus from the subjective judgments of earlier revisions to the specifics identified in the TSPA
- Approach also helps ensure consistency and completeness

Evolution of the Principal Factors

	RSS Revision 2 (VA)	RSS Revision 3	RSS Revision 4 (Preliminary)
Climate and Net Infiltration into the Mountain	√		
UZ Flow	√		
Effects of Heat on UZ Flow	√		
Seepage into Emplacement Drifts	√	√	√
In-Drift Humidity and Temperature	√		
In-Drift Chemistry	√		
In-Drift Moisture Distribution	√		
Drip Shield Performance		√	√
Waste Package Performance (Outer Barrier)	√	√	√
Waste Package Performance (Inner Barrier)	√		
Seepage into Waste Package	√		
Cladding Degradation	√		
Waste Form Degradation	√		
Dissolved Radionuclide Concentrations	√	√	√
Colloid-Associated Radionuclide Concentrations	√		√
In-Package and EBS Radionuclide Transport	√		
UZ Radionuclide Retardation	√	√	√
SZ Radionuclide Retardation	√	√	√
Wellhead Dilution	√	√	
Biosphere Dose Conversion Factors	√		√
Igneous Activity: Probability			√
Igneous Activity: Repository Effects			√

Identify Barriers Potentially Important to Waste Isolation

- Overlying rock
- Drip shield
- Waste package outer barrier
- UZ radionuclide transport barrier
- SZ radionuclide transport barrier
- Other barriers potentially important to waste isolation
  - Spent fuel cladding
  - Waste canister
  - Drift invert
  - Waste package inner barrier

Identify Potential Vulnerabilities To Determine the Need for Additional Measures

Potential Vulnerabilities	Remaining Work
Adequacy of treatment of model uncertainty	• Mitigate uncertainties through defense-in-depth • Ensure effects of rockfall analyzed • Increase consistency of treatment of uncertainty
Over-conservatism in some models	• Conduct studies to determine appropriateness of reducing over-conservatism in key models
Thermal loading issues	• Maintain flexible thermal design • Develop plan for decision making regarding emplacement and ventilation • Develop plan for decision making regarding closure based on results of performance confirmation testing
Potential for igneous activity at this site	• Demonstrate substantial risk margin
Reliability of complex metal barriers	• Mitigate uncertainties through defense-in-depth • Evaluate enhanced engineered barrier concepts
Consideration of peak dose	• Reduce conservatism in key models, e.g., - Solubilities of neptunium and plutonium - Waste package and EBS transport - UZ flow and transport - SZ flow and transport

Completing the Postclosure Safety Case for License Application

Element of the Safety Case	Applicability to Potential Vulnerabilities	Other Applicability	Adequacy of Current Information
Quality of the Performance Assessment	Addresses issue of uncertainty	Standard approach to assurance of safety in licensing	• Complete FEPs evaluation and trace of models to included FEPs • Address specific areas of over-optimism • Identify and address critical over-conservatisms • Ensure consistency in over-all treatment of uncertainty in TSPA
Safety Margins and Defense-in-Depth	Addresses issue of uncertainty, reliability of individual barriers	Standard approach to assurance of safety in licensing	• Ensure performance does not depend unduly on any single element of the system or combinations of elements subject to common mode failure • Evaluate designs to enhance defense-in-depth • Increase confidence in process models associated with defense-in-depth
Explicit Consideration of Potentially Disruptive Processes and Events	• Addresses issue of uncertainty associated with potentially disruptive events • Addresses issue of potential for igneous activity		• Complete evaluation of FEPs • Document basis for excluding nuclear criticality, seismic activity, water table rise • Complete analyses of igneous activity and human intrusion

Completing the Postclosure Safety Case for License Application

(Continued)

Element of the Safety Case	Applicability to Potential Vulnerabilities	Other Applicability	Adequacy of Current Information
Insights from Natural Analogues	Addresses issue of uncertainty • Long-term behavior of metal passive layers • Transport models • Effects of heat on host rock	Recommended by Nuclear Waste Technical Review Board	• Complete documentation of analogues • Transport in Busted Butte • Extent of plume at Pena Blanca • Studies of Josephenite • Analogue volcanoes
Safety Assurance • **Performance confirmation testing** • **Retrievability** • **Closure decisions** • **Postclosure monitoring**		Required by Nuclear Waste Policy Act and proposed rule	• Complete Performance Confirmation Plan • Document approach to decision making for possible retrieval and for permanent closure • Describe general approach to plans for postclosure monitoring

Relationship Between RSS and NRC's Key Technical Issues (KTIs)

- **Development process for RSS addresses those issues that are subjects of KTIs**
- **Several KTI subissues are closely linked to principal factors**
- **Other KTI subissues may be shown to be of less significance to repository performance - sensitivity analyses in progress**

Relationship Between RSS and NRC's Key Technical Issues (KTIs)
(Continued)

KTI	Related Principal Factor (Preliminary)
Total System Performance Assessment and Integration	General applicability to handling of all factors influencing performance
Container Life and Source Term	• Dissolved radionuclide concentrations • Colloid-associated radionculide concentrations • Waste package performance (outer barrier) • Drip shield performance
Radionuclide Transport	• UZ radionuclide retardation • SZ radionuclide retardation
Unsaturated and Saturated Flow under Isothermal Conditions	• UZ radionuclide retardation • SZ radionuclide retardation • Seepage into emplacement drifts
Evolution of the Near-Field Environment	To be determined – Performing analyses to determine sensitivity of performance to waste package and drip shield environments
Igneous Activity	• Igneous activity (probability) • Igneous activity (repository effects)
Structural Deformation and Seismicity	To be determined – Performing analysis of sensitivity of performance to seismic events
Repository Design and Thermal-Mechanical Effects	• Waste package performance (outer barrier) • Drip shield performance
Thermal Effects in Flow	To be determined – Performing analyses to determine sensitivity of performance to effects of coupled processes on seepage and UZ flow

Relationship Between RSS and NRC's Key Technical Issues (KTIs)

(Continued)

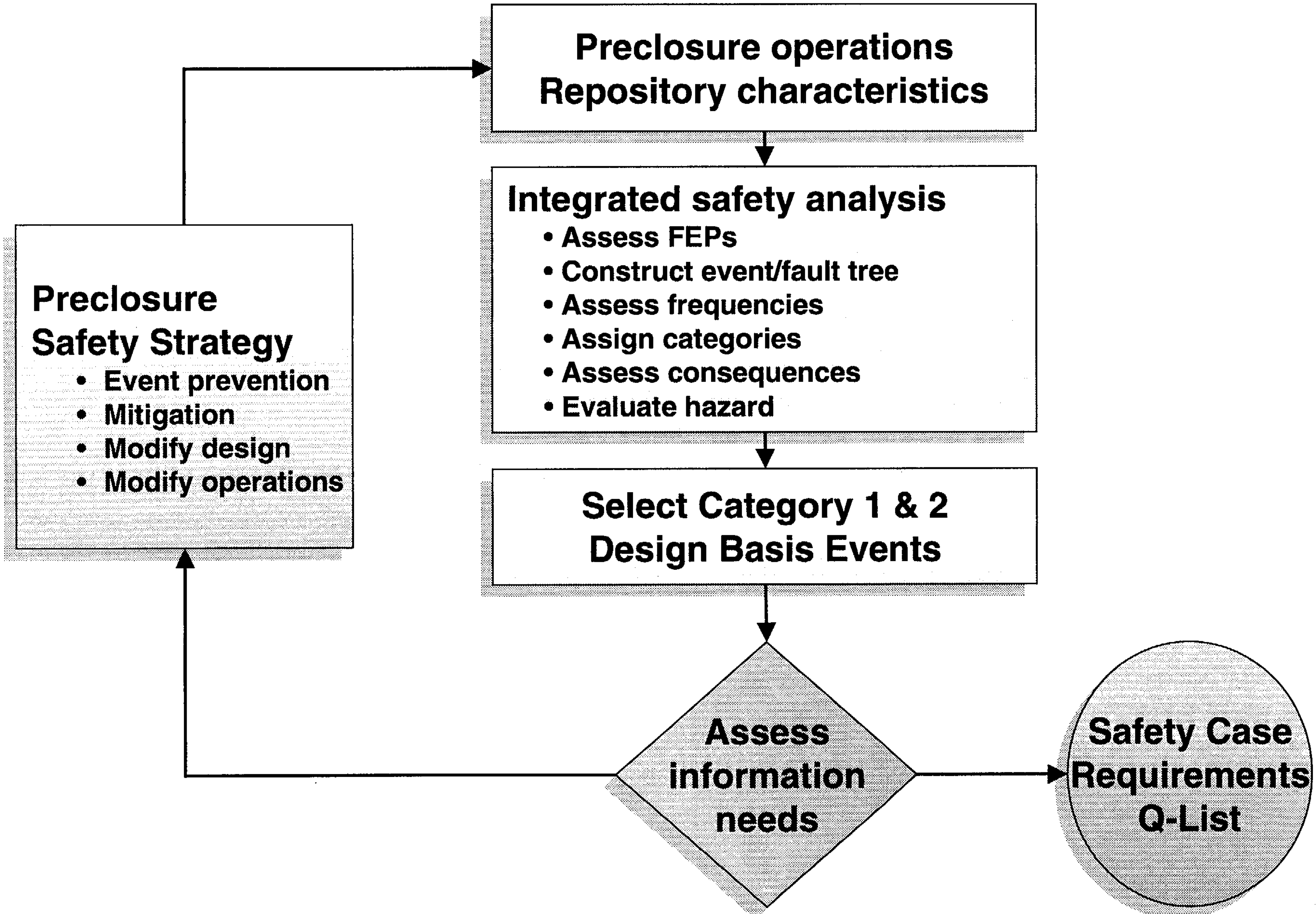
- **Plans for addressing individual KTI subissues and acceptance criteria include input from RSS**
  - Focus work before LA on reducing uncertainties in areas closely linked to performance (i.e., principal factors)
  - Will tend to bound performance in other areas
  - Information provided for each subissue will reflect importance of that subissue to safety case

Relationship Between RSS and NRC's Key Technical Issues (KTIs)

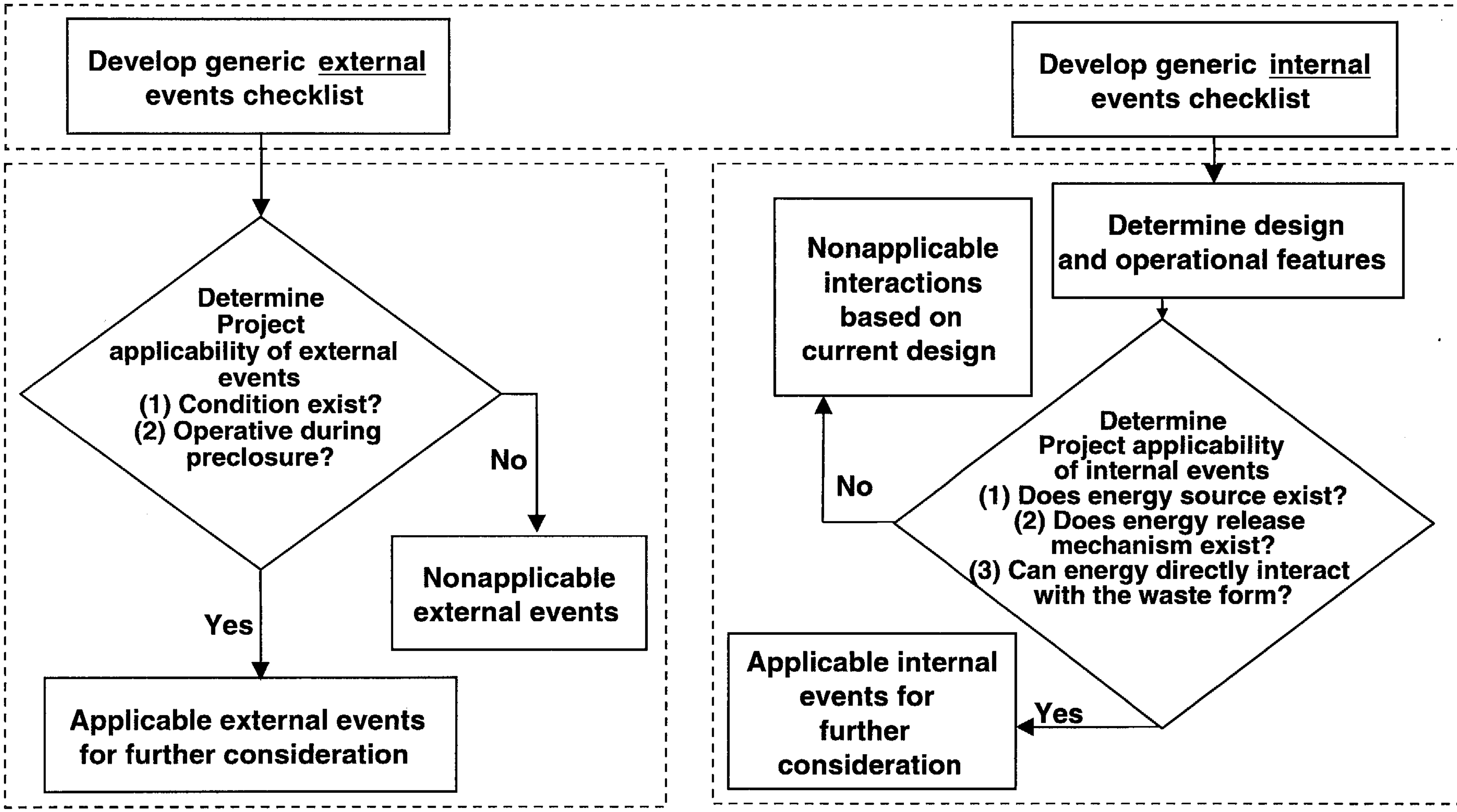
(Continued)

- NRC/DOE Technical Exchange on Yucca Mountain Prelicensing Issues on April 25 and 26, 2000 included discussions of KTI open items
- Additional interactions planned for this year will focus on KTIs in more detail

Application to Preclosure Safety



Hazard Analysis Process Flow



Management Decisions to Address Safety

- Obtain input from postclosure and preclosure safety assessments
- Determine need for mitigation or additional information
- Consider feasibility and other factors
- Select safety case for LA
- Develop requirements based on the safety case
- Develop Q-list

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Update on Repository Design and Flexibility in Operations

Presented to:
Advisory Committee on Nuclear Waste

Presented by:
Paul G. Harrington
Yucca Mountain Site Characterization Office
U.S. Department of Energy

June 14, 2000

YUCCA MOUNTAIN PROJECT

Update on Repository Design and Flexibility in Operations

- **Purpose**
  - Summarize recent design changes
  - Identify uncertainties in thermally-driven processes and approach to treating them
  - Discuss operational flexibility

Recent Design Changes

- **Subsurface**
  - Drifts reoriented; ventilation shafts moved
    - Reduces cost and complexity of construction
    - Reduces size of design basis rock
  - Backfill removed
    - Creates margin to cladding temperature limit
    - Simplifies closure operations
    - Reduces dust and handling hazards
  - Drip shield emplacement gantry concept defined

Recent Design Changes

(Continued)

- Waste package
  - Introduced closure lid post-weld heat treatment and peening--extends life of the waste package
  - Use of trunnion ring--facilitates surface handling
  - Smooth surface drip shield--enhances resistance from shield-to-shield expansion
  - Emplacement pallet--facilitates close emplacement in drifts

Potential Design Changes Between Site Recommendation (SR) and License Application (LA)

- Waste handling building
  - Preliminary results from conceptual re-design study
  - Reduced number of overhead cranes from 16 to 4
  - Decreased potential drop height from ~8 to ~1 m
  - Reduced number of lifts from 12 to 3
  - Eliminated the wet pools
    - Eliminates potential spills
    - Reduces personnel exposure
  - Added process shielding to the waste package
  - Eliminated temporary scaffolding in cask preparation area

Thermal Uncertainty Issues

- Thermally-driven processes introduce uncertainties in predictions of repository performance
  - Physical-chemical changes are a function of time and temperature
  - The magnitude, and duration of coupled thermal-hydrologic-mechanical-chemical (THMC) effects increase with increasing temperature
  - Repository time frame is much longer than testing period
  - Thermal disturbance is over a larger distance than probed by tests
- Performance predictions for SR/LA must include uncertainties in representations for thermally-sensitive processes
- Design decisions must consider impact of uncertainties

Near-Field Environment Processes

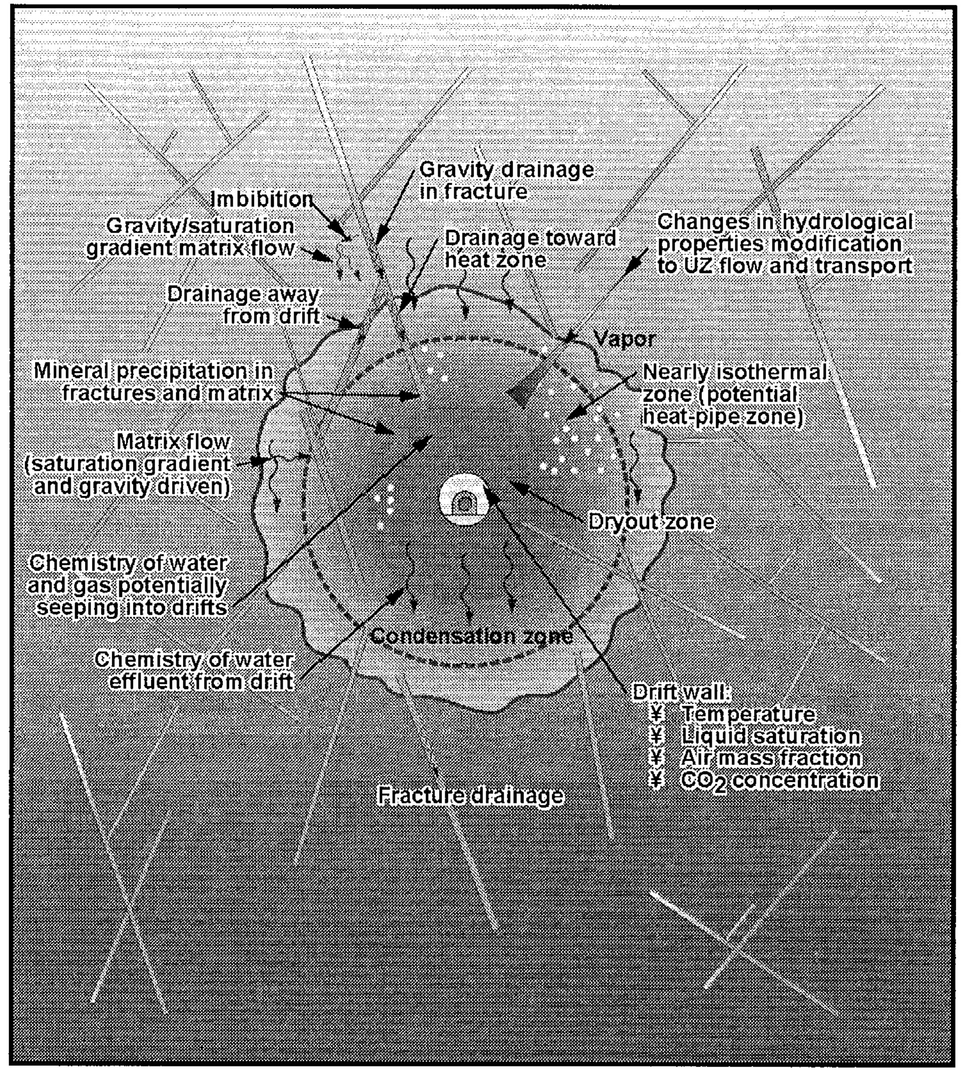
SR Design Features:
Preclosure period: 50 years
Thermal Loading: 60 Metric Tons Heavy Metal (MTHM)/acre
Waste package spacing: 0.1 m
Drift spacing: 81 m

Predictions:
Maximum "boiling" extent occurs at approximately 200 - 500 years

"Boiling" front occurs about 12 m into host rock

Below "boiling" at drift wall at approximately 1,200 - 2,000 years

Drift wall approximately 50°C at 10,000 years



Corrosion

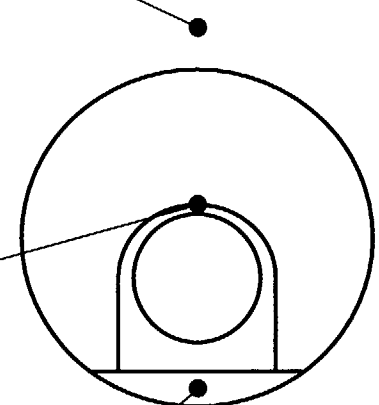
SR Design Conditions

Predictions Required:

Near-Field Host Rock
Max. T > 96°C
Min. RH << 50%
Precipitates/Salts Accumulation which can subsequently interact with water flow and chemistry

Drip Shield/Waste Package Surfaces
Max. T > 96°C
Min. RH << 50%
Precipitates/Salts Which can result in concentrated solutions (>10 molal) at the surfaces

Invert
Maximum T > 96°C
Precipitates/Salts Accumulation in fractures (plugging) which can result in localized pooling of water



Corrosion Resistance Material (CRM) Corrosion
General and localized corrosion:
- Low dependence on temperature for aqueous conditions

Pitting and crevice corrosion not strongly driven at expected aqueous conditions:
- Continue to test

Stress corrosion cracking:
- Temperature-dependent near 100°C, but less otherwise
- Testing chemistry dependence

Phase segregation:
- Low for temperatures below 260°C
- Behavior obtained from testing

Legend
T **Temperature**
RH **Relative Humidity**

Waste Form Degradation

- Degree of cladding degradation--Rate of cladding degradation increases rapidly above 350°C
- Solubility--mildly temperature-dependent
- Degradation rates--Uranium oxide (UO_x) dissolution rate varies by one order of magnitude between 25°C and 96°C

Testing and Analyses to Address Thermally-Induced Uncertainties

Category	Description	Testing and Analyses
Hydrologic	• Volume and fate of mobilized water	DST, SHT, LBT, CDTT, geothermal analogues, Krasnoyarsk analogue, DECOVALEX project
Mechanical	• Fracturing of rock above drift • Drift stability and rockfall	DST, SHT, LBT, CDTT, DECOVALEX project
Chemical	• Mineral precipitation in fractures • Altered water chemistry (Concentration, pH, Eh) • Mineral transformation	DST, SHT, LBT, CDTT, geothermal analogues, Paiute Ridge analogue
Corrosion	• Mechanism • Rate	Laboratory corrosion testing, iron meteorite analogues
Waste Form Degradation	• Degree of cladding degradation • Solubility • Rate	Laboratory waste form testing, laboratory cladding testing, laboratory solubility testing, Pena Blanca analogue

Testing Analysis Table.cdr

Legend:
DST - Drift Scale Test - Ongoing
SHT - Single Heater Test - Completed
LBT - Large Block Test - Completed
CDTT - Cross Drift Thermal Test - Planned
DECOVALEX - DEvelopment of COupled models and their VALidation against EXperiments in nuclear waste isolation

Treatment of Uncertainties in Total System Performance Assessment-Site Recommendation (TSPA-SR)

Category	Uncertainty Parameter	Primary Effects on Performance
Hydrologic	• Flow Focusing factor • Condensation	• Seepage fraction and amount • Water flux on waste package
Mechanical	• Fracture flow characteristics • Rockfall size and frequency	• Seepage fraction and amount • Dripshield stresses and stress induced cracks
Chemical	• Fracture flow characteristics • Near field geochemistry • Fracture and matrix transport characteristics	• Seepage fraction and amount • In-drift geochemistry • Advective travel time in Unsaturated Zone (UZ)
Corrosion	• In-drift geochemistry • Waste package temperature	• General corrosion, crevice corrosion and stress corrosion cracking initiation and rate • Rate of general corrosion
Waste Form Degradation	• Cladding temperature and chemistry • Radionuclide solubility • Waste form alteration	• Clad unzipping rate and fraction of fuel exposed • Dissolved radionuclide concentrations and colloid stability • Stability of secondary phase

Testing Analysis Table.cdr

Ongoing Analysis and Treatment of Uncertainties

- DOE's strategy for addressing uncertainties affecting postclosure safety has been developed and communicated [Abe Van Luik presentation to Nuclear Waste Technical Review Board (NWTRB), January 25-26, 2000]
- Treatment of uncertainties in inputs to performance assessment is currently being synthesized and documented for Site Recommendation Consideration Report (SRCR)
- Guidance will be developed for treatment and documentation of uncertainties for LA

Approach to Uncertainty

- **Analyze quantified uncertainties**
  - Conceptual and mathematical model uncertainty
  - Variability and parameter uncertainty
  - Potentially disruptive events
  - Evolution of the system with time
  - Sensitivity and importance analyses
- **Assess all uncertainties**
  - Synthesize and assess total system performance assessment (TSPA) results
  - Assess limits in the analyses
  - Assess confidence in the models and importance of uncertainties to conclusions
  - Known but unincorporated uncertainties; unknown unknowns; potential for surprises

Approach to Uncertainty
(Continued)

- **Manage uncertainties**
  - Identify important uncertainties and options for reducing or mitigating them (e.g., additional information, conservatism in analysis, design enhancement for defense-in-depth)
  - Identify measures to build confidence
  - Retain flexibility to accommodate uncertainty; if too much risk posed by uncertainty, change design
- **Communicate uncertainties**
  - Identify sources of uncertainty, magnitudes, and potential impacts on postclosure performance
  - Provide information on assessment of uncertainty reduction or mitigation strategy
  - Use a variety of communication formats and seek feedback

Operational Flexibility and Repository Design

- Reasons for examining operational flexibility of the repository design
- SRCR/SR design
- Considerations in establishing operational flexibility
- Controlling drift thermal response
  - Selecting operational variables
    - Staging receipt/emplacement
    - Waste package spacing
    - Ventilation duration
  - Repository operating curves--trade-offs among variables

Reasons for a Flexible Repository Design

- **Program objective is to have a flexible SRCR/SR design to accommodate future:**
  - Policy decisions
  - Alternative technical objectives
  - New information
  - Other considerations

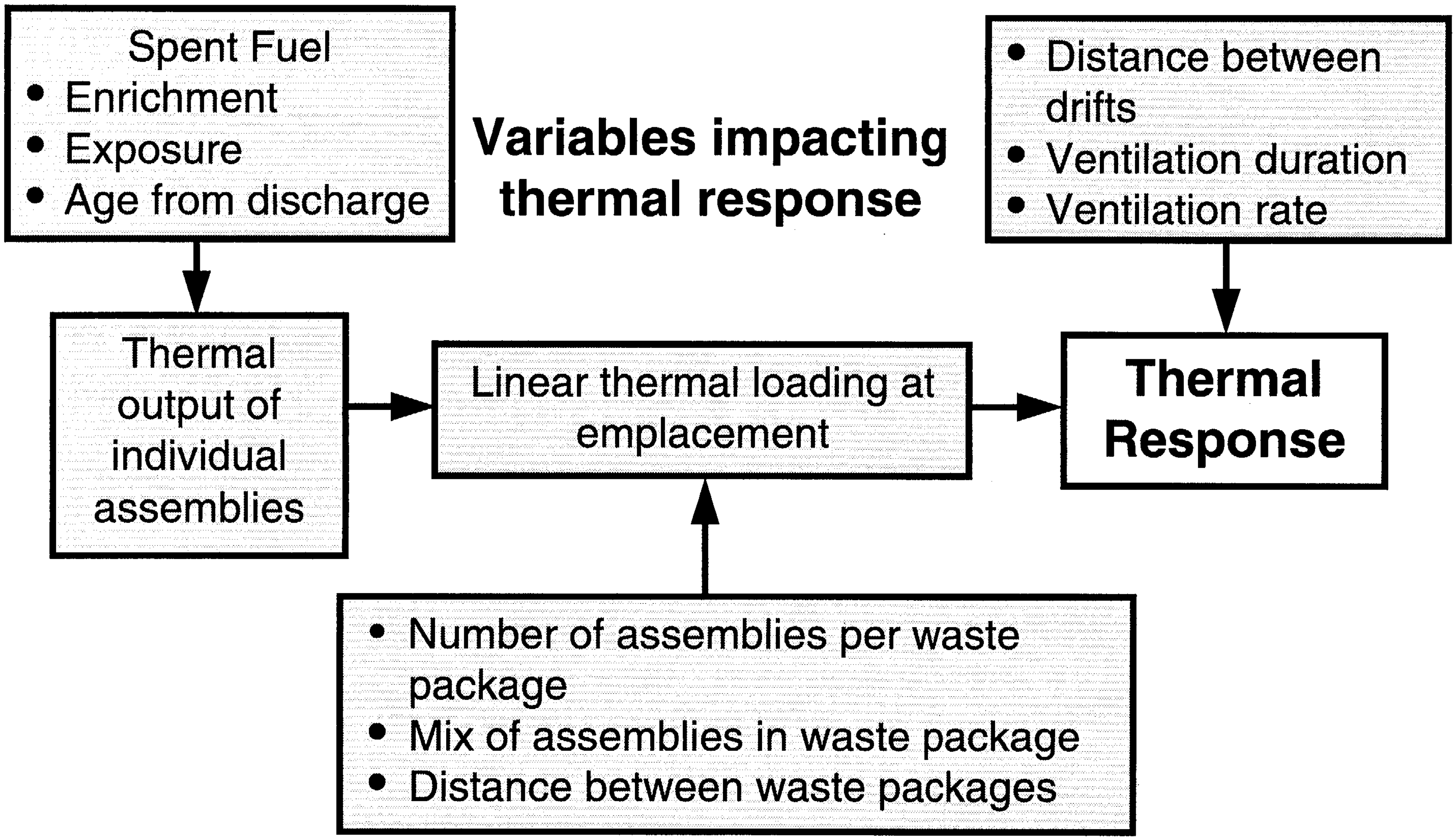
SRCR/SR Design

- **Design requirements**
  - Cladding to remain below 350°C
  - Water to drain between drifts
- **Design features**
  - 81 m between drifts
  - ~7.6 kW average waste package power
  - ~1.5 kW/m average linear power density at emplacement
  - 15 m^3/s ventilation rate
  - Drip shield
  - Average 26 years old fuel at receipt

SRCR/SR Design
(Continued)

- **Operational features**
  - 0.1 m distance between waste packages
  - 50-year preclosure period
  - No staging
- **In the last drift loaded:**
  - Postclosure wall temperatures about 200°C
  - Evaporation fronts advance ~12 m

Considerations in Establishing Operational Flexibility



Initial Screening to Identify Operational Features

- Enrichment--cannot be changed by the Program
- Exposure--cannot be changed by the Program
- Age from discharge--addressed by staging receipt/emplacement

Initial Screening to Identify Operational Features
(Continued)

- **Number of assemblies per waste package--changing distance between waste packages has equivalent effect**
- **Blending dissimilar assemblies in waste package--blending of similar assemblies already in SR design basis**
- **Distance between waste packages--can be operationally controlled**

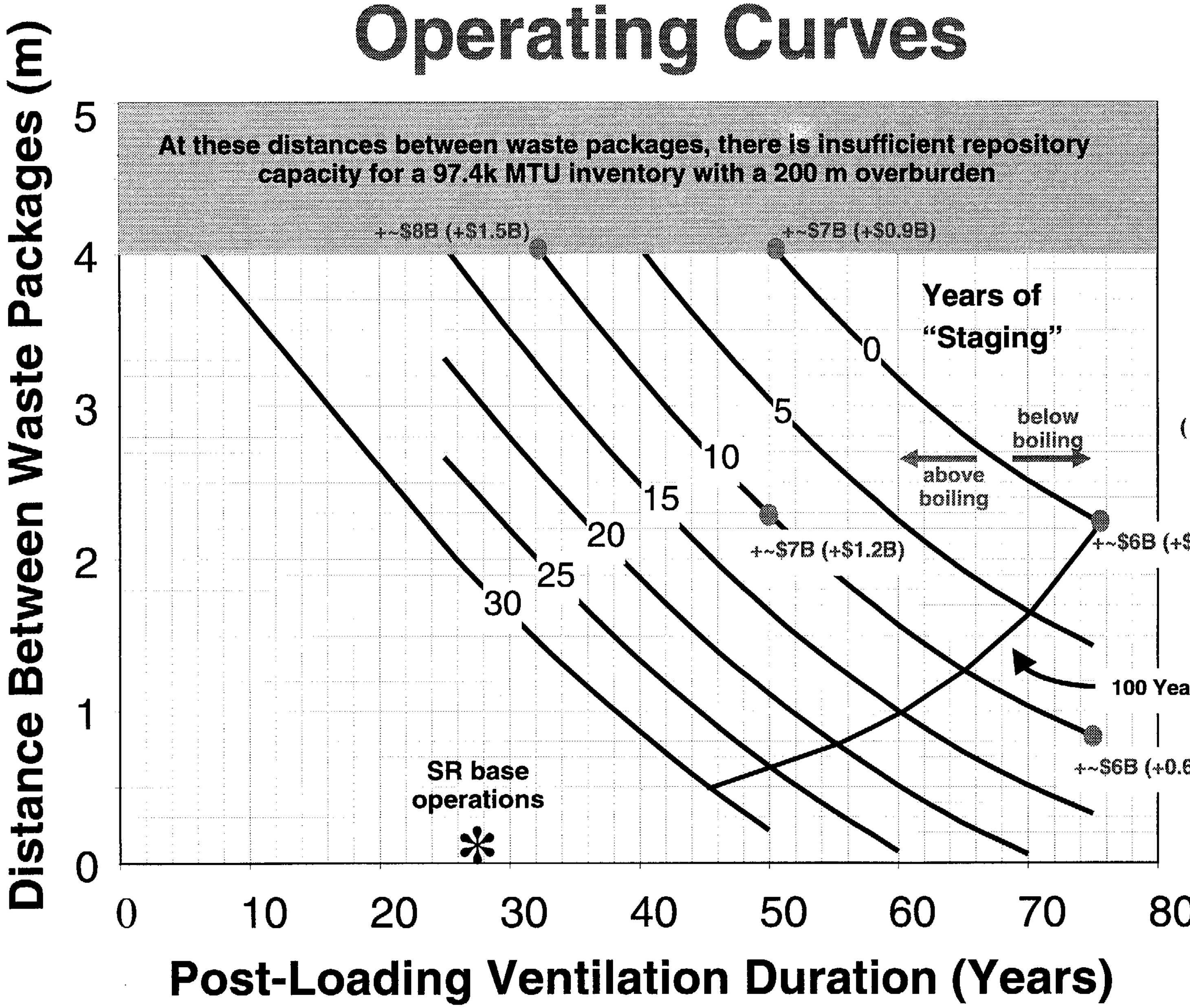
Initial Screening to Identify Operational Features
(Continued)

- **Distance between drifts--has relatively little impact on predicted drift wall temperatures for reasonable variations in SR design**
- **Ventilation duration--can be operationally controlled**
- **Ventilation rate--staging equivalent to 100% ventilation efficiency bounds impact**

Non-Boiling Operations Considerations

- A first-order parametric study has been conducted to determine feasibility of operating with the average drift wall below 96°C
- Staging, increasing waste package spacing, and increasing ventilation duration can be adjusted to keep the drift wall below 96°C
- Some hot spots exist
  - Where in-drift components contact drift invert
  - Opposite high-power waste packages

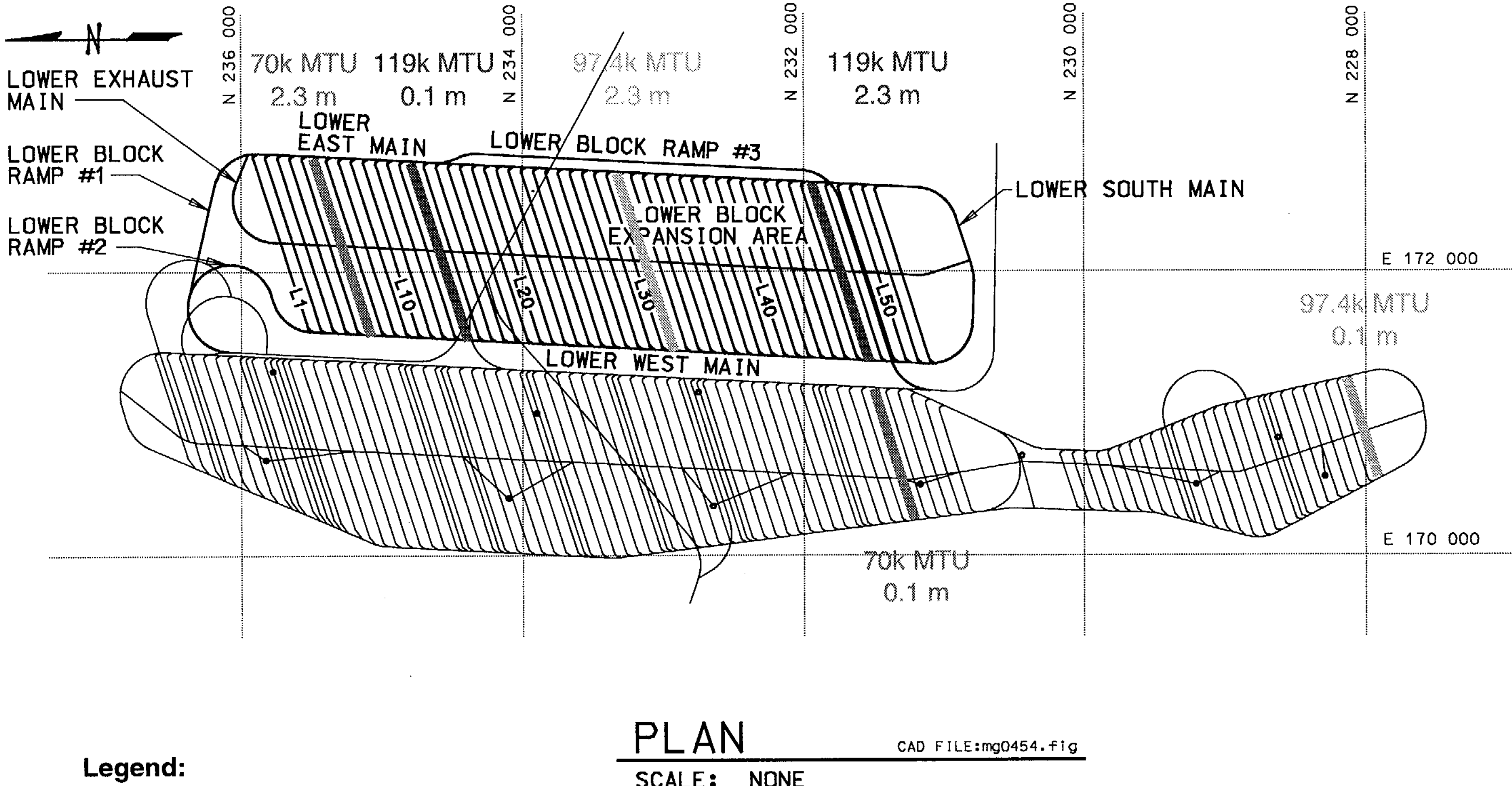
Below-Boiling Repository Operating Curves



Avg. age of Commercial Spent Nuclear Fuel (CSNF) at receipt = 26 yrs.

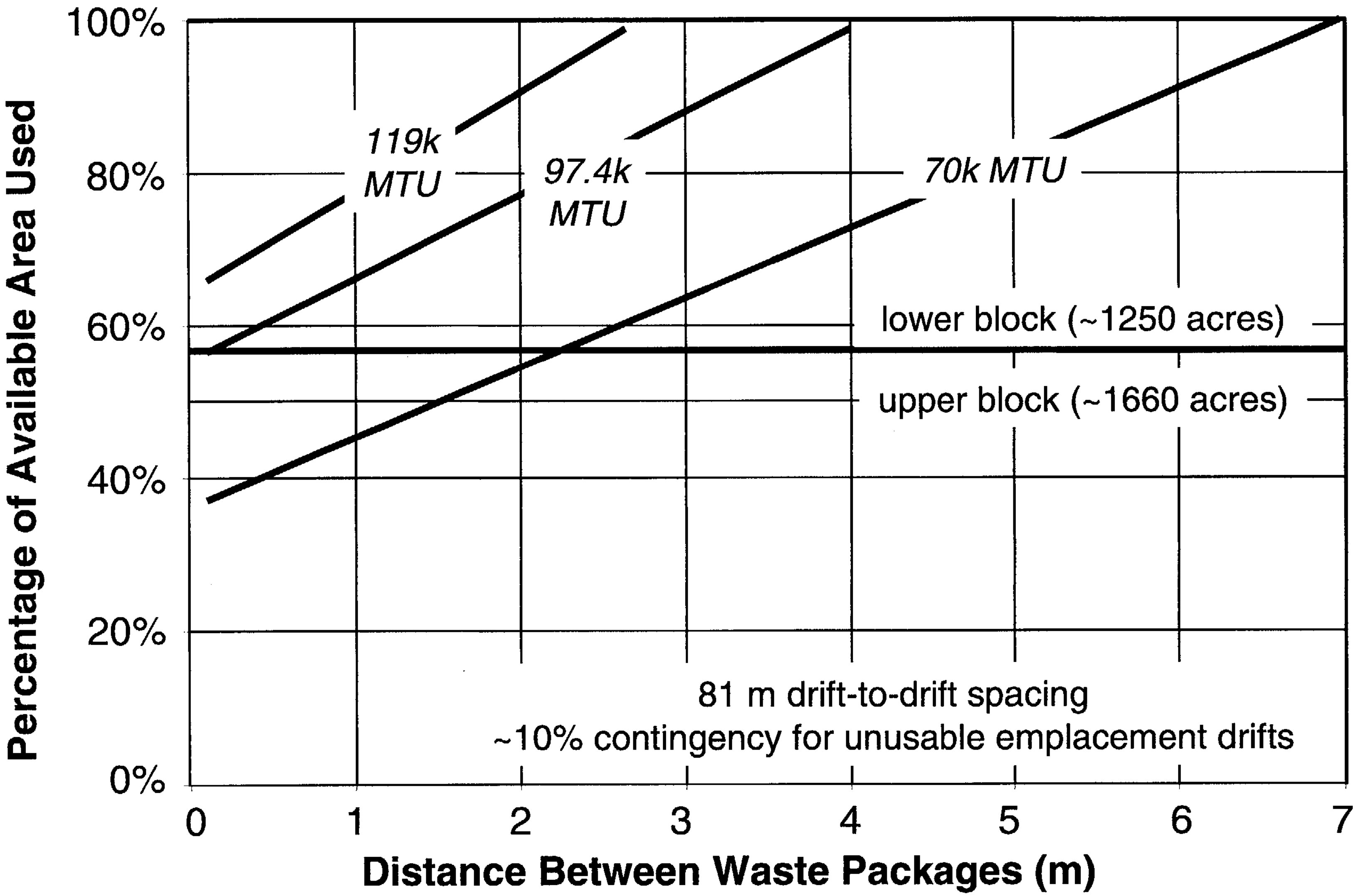
Costs Relative to SR Base Operations Mode in 1999$
( ) = (Net Present Value)

Repository Layout



Legend:
MTU - Metric tons uranium

Utilization of Repository Capacity



Summary of Repository Operating Modes

- This initial assessment indicates that the SRCR/SR design is flexible and resilient enough to operate such that the drift wall stays below the boiling point of water
- Refinements that will improve this assessment:
  - Specific, rather than average, decay curves
  - 3-Dimensional, instead of 2-Dimensional, calculations

Implications to Operational Flexibility and Repository Design

- **SRCR/SR**
  - Design discussion will include operational flexibility for boiling to non-boiling modes
  - TSPA will consider partial pillar above boiling as the base operation mode
  - TSPA-SR will contain sensitivity studies to address non-boiling operation mode
- **Other Activities**
  - Review the "multiple operations mode" approach with NRC
  - Review Program impacts of the identified operational features
  - Perform refined technical analyses
  - Evaluate scenarios

Summary

- Subsurface, waste package, and surface facility designs are being improved
- Uncertainties in thermally-driven processes are being identified; testing, analysis, and modeling efforts are addressing these uncertainties
- The strategy for treating uncertainties in the inputs to performance assessment has been outlined and communicated
- Guidance is being developed for uncertainty treatment, management, and communication

Summary
(Continued)

- Program objective is to have a flexible repository design for SRCR/SR
- Evaluations of the variables impacting thermal response show that the SRCR/SR design is flexible and resilient enough to operate with drift walls below boiling
- Design discussion will include operational flexibility for boiling to non-boiling modes; TSPA-SR will evaluate both modes

Backup

Possible Sensitivity and Barrier Importance Analyses to Evaluate Significance of Process Model Factors

Key Attributes of System	Process Model Factor	Possible Sensitivity Analyses	Possible Barrier Importance Analyses
Water Contacting Waste Package	Climate	• Vary timing of climate change • Vary magnitude of precipitation	• Combine maximum precipitation and maximum infiltration to maximize infiltration rate
	Net Infiltration	• Vary magnitude of infiltration	
	Unsaturated Zone Flow	• Vary magnitude of flux	• Combine 95th %ile on flow focussing factor and fracture properties to maximize seepage fraction and amount
	Coupled Effects on UZ Flow	• Vary timing/amount of dryout/reflux	
	Seepage into Emplacement Drifts	• Vary degree of flow focusing • Vary percent of repository with seeps • Vary fracture properties • Vary episodicity	
	Coupled Effects on Seepage	• Vary changes to UZ flow	
Waste Package Lifetime	In-Drift Physical and Chemical Environments	• Vary T/RH • Vary rockfall/location of rockfall • Vary chemistry on drip shield (DS) (salt/dust) • Vary chemistry on waste package (WP) without DS present	• Combine 95th %ile on flow focussing factor and fracture properties to maximize seepage fraction and amount
	In-Drift Moisture Distribution	• Vary range of moisture on DS • Vary condensation under DS • Vary range of moisture on WP	
	Drip Shield Degradation and Performance	• Vary corrosion rate • Evaluate drip shield separation • Evaluate leakage through drip shield joints	• Combine 95th %ile on rockfall, titanium degradation rate, indrift chemistry, and hydrogen-induced cracking (HIC) to minimize dripshield lifetime
	Waste Package Degradation and Performance	• Evaluate phase stability/aging • Evaluate effect of phase stability on local/crevice corrosion • Vary stress and stress intensity at closure weld • Vary threshold stress • Vary corrosion rate • Vary initial defect size and probability • Vary heat sensitization near welds • Evaluate stainless steel barrier credit • Evaluate co-dependence of DS/WP failure • Vary microbiologically-induced corrosion (MIC)	• Combine 95th %ile on initial defects, stress state, threshold stress, corrosion rate, MIC, and aging to minimize waste package lifetime

Possible Sensitivity and Barrier Importance Analyses to Evaluate Significance of Process Model Factors

(Continued)

Key Attributes of System	Process Model Factor	Potential Sensitivity Analyses	Barrier Importance Analyses
Radionuclide Mobilization and Release from the Engineered Barrier System	Radionuclide Inventory	• Vary burnup/age variability across repository	• N/A
	In-Package Environments	• Vary water chemistry • Evaluate evaporation from breached waste packages during thermal period	
	Cladding Degradation and Performance	• Vary degradation rate • Vary perforations	• Combine 95th %ile on initial defects, unzipping rate, and Fluoride content to minimize cladding lifetime
	CSNF Degradation and Performance	• Vary degradation rate	• N/A
	DSNF Degradation and Performance	• Vary degradation rate	
	DHLW Degradation and Performance	• Vary degradation rate	
	Dissolved Radionuclide Concentrations	• Vary plutonium, neptunium solubility • Evaluate secondary phases	• Combine 95th %ile colloids, pH, solubility, diffusion coefficient to maximize radionuclide mobilization and release
	Colloid-Associated Radionuclide Concentrations	• Vary fraction of irreversible colloids	
	In-Package Radionuclide Transport	• Vary fraction of water removed from waste package	
	EBS (Invert) Degradation and Performance	• Vary sorption in invert • Vary diffusion coefficient in invert • Vary saturation of invert	

CSNF = Commercial spent nuclear fuel
DSNF = DOE spent nuclear fuel
DHLW = Defense high-level waste

Possible Sensitivity and Barrier Importance Analyses to Evaluate Significance of Process Model Factors
(Continued)

Key Attributes of System	Process Model Factor	Potential Sensitivity Analyses	Barrier Importance Analyses
Transport Away from the Engineered Barrier System	UZ Radionuclide Transport (Advective Pathways; Retardation; Dispersion; Dilution)	• Vary matrix diffusion • Vary colloid filtration • Evaluate spatial variation of properties • Vary sorption	• Combine 95th %ile on sorption coefficient (K_d), matrix diffusion, flow rates to minimize transport times in the unsaturated zone
	SZ Radionuclide Transport	• Evaluate effect of climate change on pathways and flux • Evaluate water table rise • Vary flux • Evaluate flowing interval spacing • Vary amount of alluvium • Vary K_d in alluvium • Vary colloid filtration in alluvium	• Combine 95th %ile on K_d, matrix diffusion, percent alluvium, flow rate to minimize transport times in the saturated zone
	Wellhead Dilution	• Vary volume of water used by critical group	• N/A
	Biosphere Dose Conversion Factors	• Vary biosphere dose conversion factors (BDCF)	
Effects of Potentially Disruptive Processes and Events	Probability of Volcanic Eruption	• Vary probability	• N/A
	Characteristics of Volcanic Eruption	• Vary event eruption volume	
	Effects of Volcanic Eruption	• Vary waste particle diameter	
	Atmospheric Transport of Volcanic Eruption	• Vary wind speed and direction	
	Biosphere Dose Conversion for Volcanic Eruption	• Vary BDCF	
	Probability of Igneous Intrusion	• Vary probability	
	Characteristics of Igneous Intrusion	• Vary number of packages affected	
	Effects of Igneous Intrusion	• Vary degree of degradation of waste package	

YUCCA MOUNTAIN PROJECT

Proposed Yucca Mountain Site Suitability Guidelines, 10 CFR 963

Presented to:
Advisory Committee on Nuclear Waste

Presented by:
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Office of Civilian Radioactive Waste Management

June 14, 2000

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Proposed Yucca Mountain Site Suitability Guidelines

- Under the 11/30/99 proposal, DOE may find that the site is suitable if the required evaluations show that the proposed repository is likely to meet applicable radiation protection standards for the preclosure and postclosure periods
- A positive suitability determination will be one basis for a decision by the Secretary of Energy whether to formally recommend the site to the President for development
  - The Secretary must consider other information for a Site Recommendation, as required by the NWPA

Proposed Yucca Mountain Site Suitability Guidelines, 10 CFR 963

- DOE is proposing to revise the Guidelines for several reasons, including:
  - to align the suitability guidelines with the latest science and scientific analytical techniques for assessing repository performance
  - to be consistent with the revisions proposed by the program's regulators (EPA and NRC)
  - to address public comments raised on the Department's 1996 proposal to amend the guidelines

Proposed Yucca Mountain Site Suitability Guidelines, 10 CFR 963

- 10 CFR 960 is proposed to be left in place for possible future use in selecting among candidate repository sites for site characterization, but would no longer be applicable for determining the suitability of Yucca Mt.
- A new part 963 is proposed to establish Site Suitability Guidelines specific to Yucca Mt.

Proposed Yucca Mountain Site Suitability Guidelines, 10 CFR 963

- Proposed 963 presents the criteria and methodologies for assessing the performance of a potential Yucca Mt. repository in meeting preclosure and postclosure applicable radiation protection standards
- DOE proposed preclosure approach utilizes a preclosure safety evaluation that is generally consistent with NRC Proposed 10 CFR 63

Proposed Yucca Mountain Site Suitability Guidelines, 10 CFR 963

- DOE proposed postclosure approach is based on the use of total system performance assessment and is generally consistent with the regulatory structure in EPA Proposed 40 CFR 197 and NRC Proposed 10 CFR 63, and the findings of the 1995 NAS Report - Technical Bases for Yucca Mt. Standards

Proposed Yucca Mountain Site Suitability Guidelines, 10 CFR 963

- Proposed post closure suitability criteria represent the characteristic traits pertinent to assessing the performance of a repository at Yucca Mountain
- Proposed criteria include physical processes of water falling on Yucca Mountain, moving into the mountain, down through the unsaturated zone, from the repository level to the saturated zone and from there to the outside environment

Proposed Yucca Mountain Site Suitability Guidelines, 10 CFR 963

- At repository level, the water would be affected by the physical processes associated with the repository, the waste packages and the waste forms
- Disruptive events could potentially affect these physical processes and, therefore, are proposed to be considered

Proposed Yucca Mountain Site Suitability Guidelines, 10 CFR 963

- Proposed disruptive processes and event criteria relate to those processes and events that could potentially release radionuclides to the environment, or otherwise adversely affect the performance of the system
- Proposed disruptive processes and events criteria:
  - Volcanism
  - Seismic events
  - Nuclear criticality
  - Inadvertent human intrusion

Proposed Yucca Mountain Site Suitability Guidelines, 10 CFR 963

- Proposed post closure suitability criteria:
  - Site characteristics
  - Unsaturated-zone characteristics
  - Near-field environment characteristics
  - Engineered barrier system degradation characteristics
  - Waste form degradation characteristics
  - Engineered barrier system, degradation, flow, and transport characteristics
  - Unsaturated-zone flow and transport characteristics
  - Saturated-zone flow and transport characteristics
  - Biosphere characteristics

Proposed Yucca Mountain Site Suitability Guidelines, 10 CFR 963

- Public comment period on the proposed rule ended on 2/28/00 - nearly 100 responses from the public were received
- Two public hearings were held: Pahrump, NV (2/2/00); Las Vegas, NV (2/3/00)
- DOE considered comments received and has developed a draft final notice of proposed rulemaking

Proposed Yucca Mountain Site Suitability Guidelines, 10 CFR 963

- On 5/4/00 DOE formally requested NRC concurrence on a draft final notice of proposed rulemaking.
- In that request DOE asked NRC for "timely consideration of the draft final rule and its concurrence to allow the Department to utilize the final rule in the upcoming site recommendation process that is planned to begin this Fall."

Status of the NRC Low-Level Radioactive Waste Program--A Presentation to the Advisory Committee on Nuclear Waste

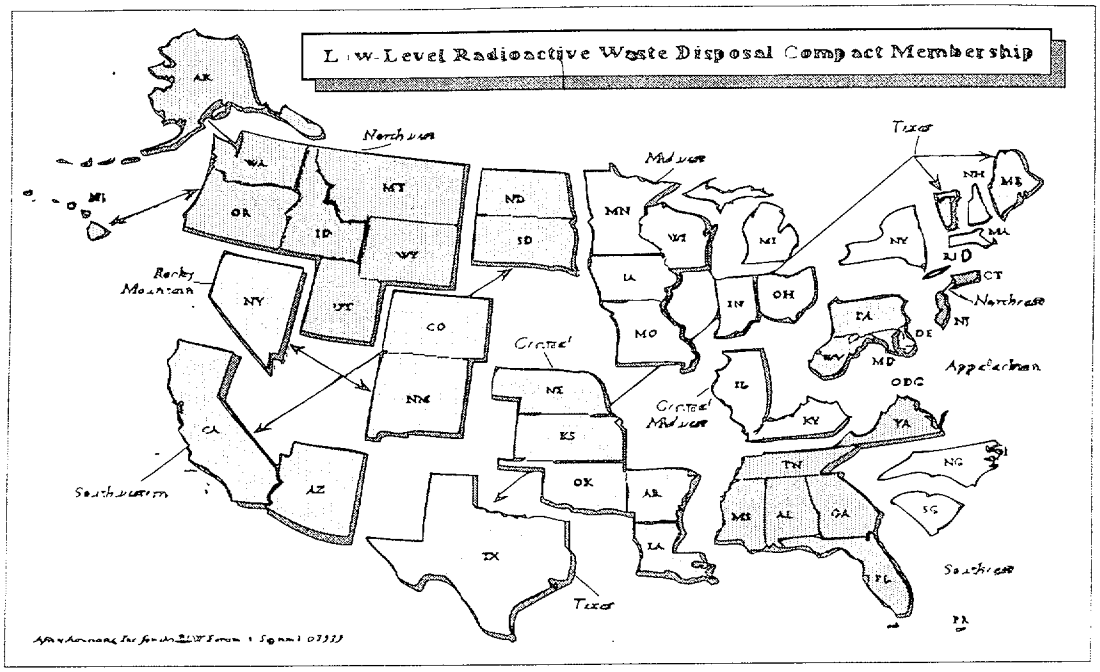
Thomas H. Essig, Chief
Environmental and Performance Assessment Branch
Division of Waste Management
Office of Nuclear Material Safety and Safeguards

June 14, 2000

Topics

- Status of National LLW Program
- Future of National LLW Program
- NRC LLW Program
- Related Activities
- Summary

Status of National LLW Program--New Facilities of States and Compacts



Status of National LLW Program--New Facilities of States and Compacts (continued)

- Texas--on October 22, 1998, the Texas regulator denied the license application for the Sierra Blanca facility.
- Nebraska--on December 18, 1998, the Nebraska regulator denied the license application for a facility in Boyd County, NE.
- California--on June 2, 1999, the Governor announced formation of Advisory Group on LLW to examine alternatives to Ward Valley facility. Ward Valley is no longer being considered.
- "Efforts by States and compacts to develop new facilities have essentially stopped."--GAO Report, September 1999.

Existing Facilities, States and Compacts

- U.S. Ecology disposal facility in Richland WA provides disposal for 11 western States.
  - Northwestern and Rocky Mountain Compacts.
  - WA, OR, ID, UT, MT, WY, AK, HI (NW Compact) and NV, NM, and CO (Rocky Mountain Compact).
- Chem-Nuclear disposal facility in Barnwell, SC:
  - South Carolina about to join "Atlantic Compact" with New Jersey and Connecticut (formerly of the NE Compact).
  - No out-of-compact waste after 2008, gradual reduction in total waste disposed from 2001-2008.
  - Recent sale of Chem-Nuclear to GTS Duratek.

Private facilities

- Envirocare of Utah
  - Accepts most types of Class A waste, and low-level mixed waste, along with 11e.(2) byproduct material and NORM.
  - Has applied for license amendment to Utah Department of Environmental Quality for disposal of Class B and C LLW.
- Waste Control Specialists
  - Accepts NORM and other low-activity wastes exempt from regulation in its RCRA hazardous waste disposal cell.
  - Has discussed becoming Texas Compact site with legislature. Privately owned sites are currently prohibited from being Compact site, under existing Texas law.

Future of National LLW Program

- California LLW Advisory Group
  - Draft report issued May 25, 2000.
  - Four options
    - Ship LLW to other States, decay short-lived in California (status quo).
    - Divide the waste stream by hazard.
    - Build an assured isolation facility.
    - Build/operate a new disposal facility.
  - Group made no recommendation.
- Texas
  - Legislature will take up LLW again in January 2001.
  - Assured isolation will be considered.

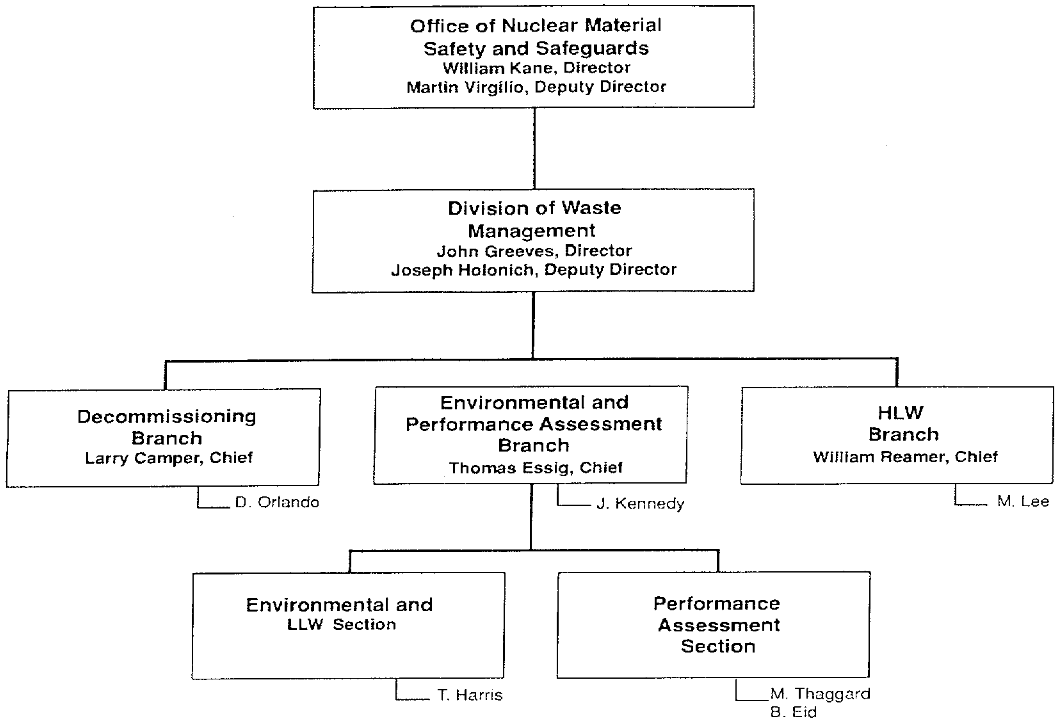
Future of National LLW Program (continued)

- Envirocare B/C application
  - Siting application approved May 3, 2000.
  - License application review initiated by Utah DEQ.
  - Legislature and Governor must also approve.
- Studies of alternatives to LLRWPAA--GAO, National Academy of Sciences
  - GAO Study: "Low-Level Radioactive Waste: States Are Not Developing Disposal Facilities," September 1999.
  - National Academy of Sciences Proposed Study: "Civilian Low-Level Radioactive Waste Disposal: Challenges and Opportunities Ahead."

NRC LLW Program

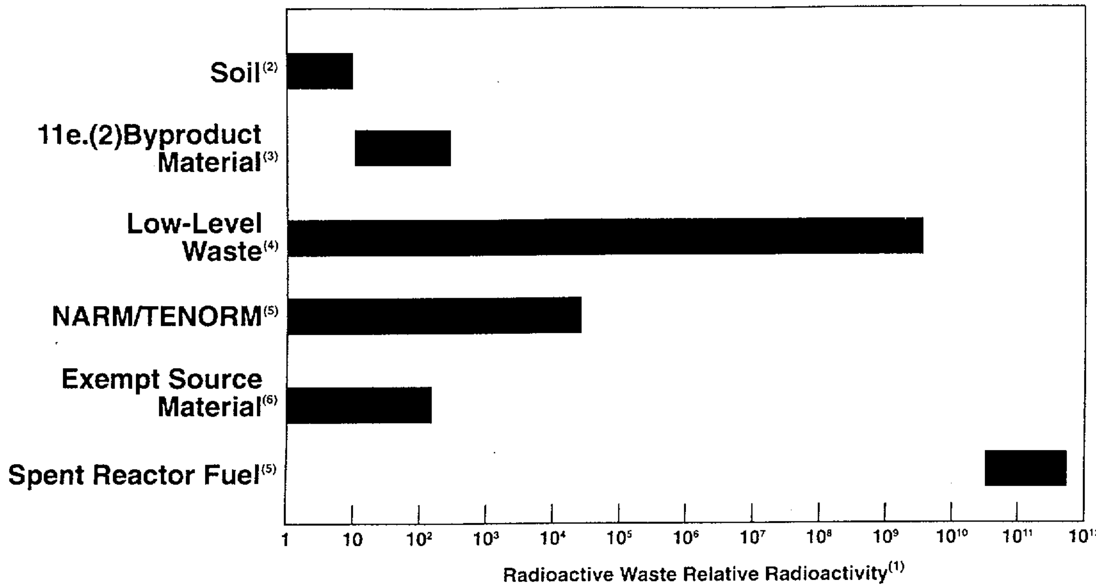
- Current direction established by Commission in 1997 based on Strategic Assessment effort.
- Rejected larger program, staff efforts to actively promote new site development.
- Current direct level of effort is ~ 3 FTE.
- ". . . staff should make every effort to maintain the core technical disciplines needed to assess LLW disposal issues, but these technical experts should be utilized in other NRC programs as appropriate."

NRC LLW Program Organization



NRC LLW Program Budget--Current Activities

- Publish Performance Assessment guidance.
- Respond to State requests for assistance.
- Review onsite disposal requests under 10 CFR 20.2002.
- Review import/export applications.
- Coordinate with EPA on mixed waste rulemakings.
- Develop rule for GTCC storage at nuclear power plant dry storage facilities (ISFSIs).
- Participate in IMPEP reviews.
- Support other agency programs in LLW disposal issues--inspections, guidance interpretation, OCA, OPA, etc.



(1) Relative radioactivity is the ratio of the radioactivity concentrations for each material divided by the low-end for soil radioactivity. Numbers are approximate.

(2) Range for soils is from National Council on Radiation Protection and Measurements Report 50, "Environmental Radiation Measurements."

(3) 11e.(2) byproduct material is defined by its origin, not by any lower or upper bounds on concentrations. Byproduct material derived from ores with very high uranium or thorium content would be slightly higher than shown.

(4) Low-level wastes are defined in part by their origin, and some may be just above background levels in soil. Upper limits for Class A, B, and C LLW are defined in 10 CFR Part 61, but are not shown. Upper limit for LLW is average of Greater Than Class C waste in DOE Integrated Data Base Report (see note 5).

(5) Spent fuel from DOE Integrated Data Base Report, 1995, Revision 12, DOE/RW-0006. NARM/TENORM from same report and "An Assessment of the Disposal of Petroleum Industry Norm in Nonhazardous Landfills," Argonne National Laboratory, October 1999. Report No. DOE/BC/W-31-109-ENG-38-8.

(6) 0.05% by weight uranium or thorium.

Comparison of Radioactivity Levels in Radioactive Wastes.

NRC LLW Program--Related Activities

- Alternatives to 10 CFR Part 61 facilities
  - Entombment of nuclear power reactor LLW
  - Rubblization
  - Use of uranium mill tailings impoundments for disposal of similar LLW (SECY-099-012)
  - Assured isolation facilities
  - Clearance of solid materials
  - Low-end source material rulemaking (SECY-99-259)
- FUSRAP--not regulated by NRC, but staff receives requests for assistance, 2.206 petitions.

Summary

- States and compacts have been unable to develop new facilities.
- Disposal capacity is available today, future is uncertain.
- Staff continues to implement its LLW program responsibilities as directed by Commission.
- Staff supports other in-house initiatives that involve alternatives for management and disposal of LLW.
- NRC supports outside efforts to examine alternatives.