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OFFICIAL TRANSCRIPT OF PROCEEDINGS

NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON NUCLEAR WASTE

Title: 100TH ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW) MEETING

Docket No.:

TR08 (ACNW)
RETURN ORIGINAL
TO BJWHITE
M/S T-2E26
415-7130
THANKS!

Work Order No.: ASB-300-249

LOCATION: Rockville, Maryland

DATE: Wednesday, April 22, 1998

PAGES: 160 - 360

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UNITED STATES NUCLEAR REGULATORY COMMISSION'S
ADVISORY COMMITTEE ON NUCLEAR WASTE

APRIL 22, 1998

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Nuclear Waste, taken on April 22, 1998, as reported herein, is a record of the discussions recorded at the meeting held on the above date.

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UNITED STATES NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON NUCLEAR WASTE

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100TH ADVISORY COMMITTEE ON

NUCLEAR WASTE (ACNW) MEETING

U.S. Nuclear Regulatory Commission
Two White Flint North, Room 2B-3
11545 Rockville Pike
Rockville, Maryland 20852-2738

Wednesday, April 22, 1998

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

MEMBERS PRESENT:

B. JOHN GARRICK, Chairman, ACNW
GEORGE HORNBERGER, Member, ACNW
CHARLES FAIRHURST, Member, ACNW
RAYMOND G. WYMER, Member, ACNW

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

SHER BAHADUR, Waste Management Branch

WILLIAM R. OTT, Waste Management Branch

THOMAS NICHOLSON, Waste Management Branch

JACOB PHILIP, NM

PHILLIP REED, Waste Management Branch

LINDA VEBLEN, Waste Management Branch

EDWARD O'DONNELL, Waste Management Branch

RALPH CADY, Waste Management Branch

PROCEEDINGS

[8:30 a.m.]

CHAIRMAN GARRICK: The meeting will now come to order. This is the second day of the 100th 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, Raymond Wymer, and Charles Fairhurst.

Today the committee will first discuss/review the NRC staff's total system sensitivity analysis for Yucca Mountain; discuss staff guidance being prepared for the review of the DOE's Yucca Mountain viability assessment; hear comments from representatives of the Nuclear Energy Institute; and, continue our preparation of ACNW reports.

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.

Should anyone wish to address the committee, please make your wishes know to one of the committee's staff. As usual, it is requested that each speaker use one of the microphones, identify himself or herself, and speak with sufficient clarity and volume so that he or she can be readily heard.

Because of some recording problems yesterday, we

are carrying over some business matters to today to bring up. We want to do a couple of things. We want to note some items of interest and, also, given that this is the 100th meeting of this advisory committee, it occurred to us that some sort of recognition of that in the record would be appropriate. So we will also do that.

As far as items of current interest are concerned, Energy Secretary Pena announced Monday, April 6, 1998, that he will leave his post effective June 30, to return to private life. He said he will seek employment in private business and will not seek an elective office.

The Senate, on April 1, 1998, approved a measure consenting to a low level radioactive waste compact which provides for waste from Texas, Maine, and Vermont to be shipped to a site in Texas. The bill now goes to a House/Senate Conference committee.

The Department of Energy says it plans to open the waste isolation pilot plant near Carlsbad, New Mexico, by May 29.

In a paper published in Science on March 27, 1998, a contractor to the Center for Nuclear Waste Regulatory Analyses documents observations of horizontal crustal movement made over a six-year period by global positioning system surveys of the Yucca Mountain region. The one-quarter extension in six years -- that is about a

millimeter per year -- is about three to four times faster than the average velocity in the basin and range province.

The researchers from Cal Tech and Harvard Astro Physical Observatory hypothesize that the region is undergoing a period of enormously high strain, which may last another few tens of thousands of years. The researchers suggest that the results of conventional geological methods of determining the seismo-tectonic hazards have underestimated the earthquake and volcanic hazards that may affect Yucca Mountain.

That hypothesis is only one of several which must be evaluated and the significance of the results is being evaluated by methods of system performance analysis, under development jointly by the Division of Waste Management and the Center staffs.

Another news item of interest is that the State of Utah issues a draft license for Envirocare. In particular, the Executive Secretary of the Utah Radiation Control Board has made an initial decision to re-license the commercial low-level radioactive waste disposal facility operated by Envirocare of Utah.

In conjunction with this decision, the Executive Secretary and staff of the Division of Radiation Control in the Utah Department of Environmental Quality have prepared both a draft safety evaluation report and a draft

radioactive materials license for the facility.

Today is -- at least this week is a very special meeting of the Advisory Committee on Nuclear Waste, as it marks the commencement of the 100th meeting of the committee.

As we know, ACNW traces its history back to the Advisory Committee on Reactor Safeguards and the ACRS Waste Management Subcommittee. The subcommittee and its consultants reviewed relevant waste management issues and prepared advice for consideration by the full committee.

The growth of the DOE's repository program, the need to conserve ACRS' ability to provide high quality advice on the accurate issues, and the need for a substantially different expertise on the ACNW were the principal reasons for establishing ACNW as a separate committee.

These reasons were discussed in SECY-8791, advice to the Commission on waste management program, and have been periodically reviewed since, with the underlying reasoning still determined to be valid.

Since the inception of the ACNW in June of 1988, it has provided more than 130 written letter reports to the Chairman of the Commission. Those reports have covered a very wide spectrum of issues, from highly focused reports on topics such as considerations associated with groundwater

travel time for the proposed high level waste repository, to broader issues such as the elements of an adequate low level waste disposal program.

It has also tackled several rather thorny issues, such as the time of compliance for high and low level waste disposal facilities. While not all of our reports have gained immediate acceptance by the NRC staff, we believe they have provided the basis for good technical exchanges and have contributed to improved overall understanding and hopefully safety of the nuclear waste sites and activities.

Shortly after its inception, the committee recognized both the need for additional in-depth information and also its potential as a forum for technical interchange and open discussion of the underpinning science, thus was formed the working group concept, which, by devoting a whole day or several days to a selected topic, significantly contributed to the committee's understanding and to the quality of its advice.

Recognizing that the challenges associated with safe radioactive waste disposal are global, the committee has hosted speakers from the United Kingdom and had a full day of engagement with its counterpart committee from Germany, the RSK.

In response to requests, members have addressed groups in Asia and Europe, have visited our Canadian

neighbor's proposed disposal facilities at Panawa, and I have presented papers at several conferences and meetings aimed at addressing both high had low level waste management and disposal issues.

The committee has encouraged participation in its meetings by representatives of diverse groups and has had, therefore, the benefit of perspectives from Native American states, affected counties, industries and other Federal agencies, as well as stakeholders and other interested groups, be they proponents or opponents of the topic under consideration.

Full committee meetings have been held in Nevada and the State of Washington and individual members have visited relevant facilities in California, New York, and South Carolina.

The committee intends to even more aggressively pursue further opportunities as an integral part of its outreach program, within, of course, the constraints of the resource limitations.

We look forward to the future, fully espousing the direction of Chairman Jackson as to both the relevance of and the need for a risk-informed performance-based regulatory structure. Our record in this area, we believe, is loud and clear.

The real reason for this self-tribute is to pause,

recognize and express appreciation for the outstanding dedication and leadership of the original members of this committee; in particular, Dade Moeller, Marty Steindler, Cliff Smith, Bill Hinze, and Paul Pomeroy, who have provided a model of excellence for all of us to follow.

Finally, we, as a committee, want to publicly and for the record express our gratitude and thanks to the technical staff supporting this committee, which has performed in an exemplary manner.

So with that, unless there are some comments from the committee, we would like to proceed with our agenda. This morning we're going to devote the time to the total system sensitivity analysis for Yucca Mountain. The purpose of this briefing is to review NRC's progress in conducting total system sensitivity studies.

These studies are designed to elucidate the most important assumptions and parameters used in the NRC's total system performance assessment code, TPA code. The scope of this briefing will include an overview of the TPA code and conceptual modeling approaches, process level sensitivities, for example, for individual KTIs, results for the nominal case, including seismic and igneous scenarios, and system level sensitivity studies, including alternative conceptual models.

This review will provide a snapshot in time of the

TPI sensitivity studies which are ongoing.

It is our understanding that no final conclusions will be offered by the staff. Rather, they will provide something of a status report on what has been so far and what they plan on doing in the near future.

With that, we will turn the time over, I guess, to Keith McConnell. Keith, I will leave it to you to introduce yourself and the people who follow you.

MR. McCONNELL: Thank you, Dr. Garrick. I'm Keith McConnell. I'm the Section Chief for the Performance Assessment and Integration Section within the Division of Waste Management. We appreciate the opportunity to come back to the committee and update you on the status of our TPA activities, particularly on the auspicious occasion of completing the first century of meetings.

CHAIRMAN GARRICK: It just feels like it.

MR. McCONNELL: I believe we've been here for most of those meetings. I am the first of five presentations this morning, as Dr. Garrick mentioned. Mine is going to be the briefest and it's designed just to update you, update the committee on the status of our activities.

One thing you will note when I go through the succeeding viewgraphs is that they probably look familiar and my concept was to keep the basic frame-work the same, so there is continuity and, therefore, just update you on what

we're doing and where we are as of today, basically.

Basically, in over-viewing what we consider our integrated high level waste performance assessment program, we're using total system performance in three areas; one, to develop the regulatory frame-work for high level waste disposal, that includes evaluating the implementability of the proposed EPA standard, although the activity in that area has been relatively minor in the recent past.

We are using our TPA, our knowledge gained in TPA activities to develop a risk-informed performance based rule and, as you're probably aware, we are actively involved in developing that rule now, since we've gotten Commission direction from SECY 97-300. And we're using the TPA work to focus our review plan that would accompany the rule and basically you'll see that, as I will discuss it a little bit later, in our TSPA methodology issue resolution status report, which will eventually hopefully become the basis for our standard review plan for high level waste.

We're using TPA activities to integrate and evaluate the information across technical disciplines. That includes evaluating the issues and sub-issues within individual KTIs. We're also using TPA activities to understand the influence of uncertainties on the compliance demonstration or compliance calculation.

And as you're aware, having attended many of the

technical exchanges, we're providing our feedback to DOE on their preliminary TSPA/VA work. We've had three technical exchanges over the last year-and-a-half, I believe, and as part of our TSPA/VA review, we're going to use our TPA effort to determine the sufficiency of data necessary for a license application.

Now, just to be a little bit more specific about where we are and what we're doing. Again, this viewgraph probably looks somewhat familiar.

In developing a risk-informed site-specific rule, we're using the TPA activities to focus and explain the regulatory criteria and we're doing that now, and it was basically using our TPA activities that formed the basis of the statement in SECY 97-300 that we intended to remove the unnecessary and probably overly prescriptive design and siting criteria in 10 CFR Part 60 that's currently in place.

Again, we're ensuring a clear relationship between the NRC acceptance criteria and the compliance calculation, and that's, again, tying with the acceptance criteria in the TSPA methodology issue resolution status report to the compliance calculation that's being developed in the new 10 CFR Part 63.

And, finally, ensure that the implementing rule reflects the site knowledge of Yucca Mountain in our improved ability to assess performance over the past decade

or so. You will see that in 10 CFR Part 63, the new high level waste site-specific rule and the IRSR.

In integrating the program within NRC, we've been using TPA activities in many ways. We continue to upgrade the TPA code to be user-friendly, to incorporate the design features that DOE is considering, and also to incorporate more sophisticated knowledge. And we've done that. We've gone from 3.1.3, which we used to do the KTI level sensitivity study, to 3.1.4, upgrading it to include things like the ability to assess cladding effects on radionuclide release, and we're using 3.1.4 for the total system performance assessment or sensitivity study.

Then, finally, we're in the process, as I will discuss a little bit later, of upgrading it again for 3.2, which would be used for the TSPA formal review.

We are identifying the key elements of sub-system extraction, and that's in the TSPA methodology IRSR. It's the lower tier in that three-tier diagram that we've presented to the committee several times before. Conduct the KTI level sensitivity studies, and you've heard about that at the technical exchange and you'll hear more from Jim Firth in his presentation later today.

And conducting the sensitivity studies for the total system to assess and confirm -- assess the importance of sub-issues and confirm resolution of sub-issues. We have

used that to date as input to management in their budget considerations in weighing which sub-issues are of higher priority and which sub-issues are low priority.

So we've provided input to management in their construction of our operating plan and our budget.

Finally, the documentation of these results will be in the IRSRs as they are revised in succeeding months.

Then briefly, to go over the feedback to DOE. I don't think I need to spend too much time, because you're well familiar with what we're doing in this area. We have reviewed DOE's TSPA/VA plan and the preliminary information that they presented to us at the technical exchanges and we have used 3.1.3/4 code to look at these and identify some differing approaches in some areas where we believe that further study by DOE is necessary, and that includes approaches in matrix diffusion. It also -- with respect to data limitations, the KDs for alluvium, which are very important as far as calculating the dose once it gets down into the Amergosa Valley area, and also the neptunium solubility limits that DOE recently revised.

We believe that there might be -- there is still a difference of opinion, I believe, on whether those neptunium solubility limits are accurate.

Then, finally, the identification and treatment of disruptive events. We have significant differences in how

we're approaching that, how we're approaching scenario development, and how those scenarios will be included into the final calculation.

We will use, as I mentioned, the 3.2 code to review and independently evaluate the formal VA when it's delivered by DOE and we will provide feedback on our independent evaluations in the technical exchanges, the IRSRs, and on the formal VA, on a Commission paper that the staff will write after we get the VA.

Just to quickly run through the status of the activities within the TSPA KTI, which doesn't include the rule-making effort. Although it's still part of this section's work, this only deals with the performance assessment activities.

The 3.1.3 code was completed. It was used in the KTI sensitivity study and we're now migrating or actually have migrated to 3.1.4. The KTI level sensitivity studies are complete. We're going to combine them with the total system sensitivity studies into a final report, which we hope to get out towards the end of August.

You will hear a lot of that information -- well, you heard some of it at the technical exchange and you will hear more of it as we progress a little bit further today.

The completion of the 3.1, TPA 3.1 users manual is close upon us. It's undergoing final review at the center,

doing their QA review. I believe we've provided a draft of the users manual to your staff and we hope to train some of your staffs on the code up in the advanced computer system, or CRADO, as it's now called, in the near future.

The 3.2 code, the users manual from the 3.2 code we hope to complete by the end of September. It's basically just an evolutionary document from the 3.1 users manual.

The TSPA methodology IRSR is, again, very close to completion. It's not quite in concurrence, but it will be before the end of the week. So you should have a copy within the next couple weeks, I believe.

The importance analysis is ongoing. We've had some difficulties with that, because the senior people involved have been hospitalized, both of them, over the recent months. So we've fallen a little bit behind in that area, but we continue to make progress and we still hope to complete it, at least the conceptualization, in the April to May time-frame, in time to incorporate it into some of the thinking behind the rule-making that's now ongoing.

The KTIs will be updated in July, at least that's the current schedule, and then the Commission paper on the VA review.

So that's basically my presentation on the status.

CHAIRMAN GARRICK: Thanks, Keith. Just a couple of thoughts that might help the emphasis or the discussion

as we proceed.

I think one of the things that the committee is very interested in is something you mentioned; namely, some differences between the staff and the DOE with respect to important assumptions, like neptunium solubility, and also this whole issue of the approach that the two organizations are taking to structuring the scenarios that are under consideration.

I think, also, something that we'd like to telegraph up front that we're very interested in is how the performance assessment work is impacting the whole KTI process, and there are two things at least there. One is the KTIs themselves; has the performance assessment work given us confidence that these are the key technical issues.

There is another issue, and that is that given what we now know about how to do performance assessment, would we structure the key technical issues different than they are now structured. In other words, are they a natural outflow of the performance assessment of, if you had it to do over, would you maybe characterize them slightly different.

So those are a few things that I think we would be very interested in looking for as the day progresses. I yield to the committee if there are some other things that may be up front here, acknowledging that we want to hear

about.

MR. McCONNELL: I would just respond that you probably won't hear much about how the KTIs have been re-focused today. The emphasis today is on giving you the information that we've developed to date.

But I will tell you that we have used PA to integrate and assess the significance of sub-issues and key technical issues. But key technical issues and their construct serve a broader purpose in the program.

CHAIRMAN GARRICK: Yes.

MR. McCONNELL: So I think we're doing what you're saying we should do, but as far as moving KTIs around, I don't think that that -- because they have a broader purpose, that will occur. But we are looking at the sub-issue level and moving the sub-issues around, identifying new ones or modifying the ones we have to reflect the differences that we have with DOE as they relate to the importance to the performance calculation.

CHAIRMAN GARRICK: Yes. The thing we continue to be looking for is the confirmation that this broader look at the performance of the repository through the KTIs is, in fact, reasonable and defensible. That's what we're sort of aiming for here.

Go ahead. Excuse me.

DR. WYMER: I don't know whether anything more

will be said about the importance analysis, but that's something we have a continuing and large interest in. So insofar as anything could be said about that, we'd appreciate it.

CHAIRMAN GARRICK: It's hospitalized.

MR. McCONNELL: I think we'll probably have to come back and brief you later in the year on that, once the people on the disabled list are back to full speed.

CHAIRMAN GARRICK: Don't they have laptops?

DR. WYMER: We think it's important.

MR. McCONNELL: They do. Okay. The next presentation will be by Tim McCartin. He will talk to you about the 3.1 code. Tim is the lead for the TPA activities within the division.

MR. McCARTIN: Today I am going to try to give a brief overview of the approach of the TPA code and some of the things we're doing in the data. And by the stack of material I brought up, you can tell I could talk for the whole day. It would be very easy to do that with respect to the TPA code, although Dick, I think, has enough viewgraphs also to talk the whole day.

And we won't try to prune our presentations down and would seek questions on areas you're interested in, but we have culled a lot of information down to a little bit. Hopefully we've hit the big things, but I certainly -- I

know no one is shy here about asking questions. But we did not attempt to present everything because it clearly would get into too long of a presentation.

But in terms of the approach and hopefully based upon, Doctor, your question in terms of the integration, I will try to talk to some of the areas that -- where the KTIs and PA are working together. I think although I'm presenting this, trust me, there are at least 30 to 40 people that all worked very hard getting the TPA code together. It is very much a multi-disciplinary activity.

I know in TA, I think we've been very happy with the integration, for lack of a better word, with the other disciplines in the other KTIs.

What I will try to do is show how what we've learned with the code to date and what we've learned about what the approaches DOE is going to take in the VA, how we're working with the KTIs to modify the code to accommodate some of the things that we think we need in the code for the VA and beyond.

In terms of overall the approach, the desire is really to provide a capability and a tool and its flexibility. What we have here is you will see as I go through a number of different ways of looking at the repository. There is a lot of uncertainty with respect to which conceptual model is most appropriate to the

repository.

We want to have the flexibility to look at different designs, as well as different conceptual models. So we've tried to have developed a tool that's very flexible to accommodate a variety of approaches.

We certainly use a conservative model or data range, as appropriate, to limit the development. There are some areas that if we see are very important to performance, rather than pursuing all those areas, we go to a conservative approach or conservative data value.

I will try to bring some of those out. It's a constant effort between, well, maybe you squeeze one into the balloon and the other then bulges out and you need to tamp down a lot of different things, but we are not trying to accurately model all aspects of the repository. We're looking at -- there are some key areas that we feel we need to address adequately and those are the ones we're focusing on.

We certainly are using site information and laboratory experiments to the extent possible. I guess most important, in true PA fashion, we have a note and a caution, because it is important and I think we've raised this at the technical exchange with DOE.

Yes, we have a computer tool, if you will, to analyze the performance, but I think at this time, just

because we are looking at a particular model, it shouldn't be construed as a regulatory accepted model. For many of these approaches, we haven't done any extensive experimental work, theoretical work to develop a basis for a license application for that particular approach. That is not our job. We are not applying for a license. We are merely reviewing it.

We want to have a lot of different possibilities to look at to try to get a better understanding of the uncertainty, but just because we use a particular KD value or particular model in the TPA 3.1.4 code, it certainly can't be construed as an accepted approach to come in.

Certainly, all the insights and assertions are preliminary. We're still in the process of modifying the code. We're still analyzing the results, et cetera.

With those caveats, let me go to how we look at Yucca Mountain and from a very simple standpoint. We have the repository broken into a number of sub-areas. Each sub-area has a one-dimensional stream tube, if you will, with different layers for the different units in the unsaturated zone, which goes down to the water table.

Then there is a saturated zone stratigraphy, going out to some discharge point, where there is a receptor. It's a fairly simple view, although there are a lot of processes that are incorporated into the repository; also,

the unsaturated zone and saturated zone.

For our particular approach, we're using seven sub-areas. Why seven? It was a combination of efficiency and also looking at the stratigraphy in the unsaturated zone, in terms of where we were trying to represent some aspects of the pinching out of particular layers in the unsaturated zone. It accounts for that variation. Also, some of the seven sub-areas have variation in terms of de-percolation and variation in temperature and humidity with respect to the thermal aspect of the repository itself.

We do use a representative waste package for each sub-area. There is degradation of that waste package due to corrosion and disruptive events and mechanical fracturing, if you will, and release of radionuclides from the representative waste packages.

The saturated zone has four stream tubes that are connected to the seven unsaturated zone stream tubes. In the saturated zone, we opted to -- at one point, we had different types of tuff units. We opted to just go with a fractured tuff unit and an alluvium unit. Generally, in the saturated zone, we're looking at fracture flow only. The difference in fracture characteristics between the different units wasn't large enough to justify multiple units.

We looked at merely fracture flow in the tuff and then force media flow in the alluvium.

There are really seven main components of the 3.1.4. code, broken down to de-percolation, basically determining how much water enters repository drifts, waste package degradation; when it fails, what type of failure it is, be it due to the scenario failures, the mechanical failures, or corrosion, and how much water enters the waste package once it fails; radionuclide release, basically at what rate do radionuclides leave the EBS into the unsaturated zone; the unsaturated zone transport, moving the radionuclides from the repository to the water table; saturated zone transport, basically what is the rate of radionuclides getting to the receptor location.

We also have the direct release due to a volcanic event, looking at extrusive volcanism component, the radioactive -- the radionuclides entrained in the ash being transported to some receptor location; and, finally, the dose calculation that sums up both the groundwater component and the ground surface component, which would be the -- from the volcanic event.

I'll now try to hit on each one of those seven areas in a little more detail in terms of what the code does. It's a combination of both what the code does and some appreciations of the parameters that we're using in the code. For de-percolation, basically how much water gets into the drift, first we're looking at basically temperature

and precipitation controls of the infiltration estimates.

We're basically looking at a glacial cycle for climate change, where the precipitation gets more, the temperature gets less. That will control the rate of infiltration. We start with an initial infiltration, which is a uniform distribution varying between one and ten millimeters per year. It will increase. We have temperature and precipitation both increasing with the peak occurring somewhere around the 40 to 50,000 years from present.

The precipitation will increase by one-and-a-half -- it's a sample parameter -- one-and-a-half to two-and-a-half times present values. The temperature drops ten to five degrees below current values.

There is no consideration of runoff or transpiration in this particular calculation at this time. That is something we will be looking at in the future. That could decrease some of the infiltration rates.

We do have reflux of water. There is an assumption that there is the potential for the refluxing of water to penetrate the boiling isotherm, getting dripping on the containers earlier than, say, just the temperature alone would indicate.

However, one important thing about the reflux model right now, and it will come out with the corrosion,

our corrosion model does not account for dripping water. Our corrosion model -- when we go into aqueous corrosion, it's based on the humidity. So there is no real impact due to dripping water. If dripping water occurs early on and the waste package is intact, well, you can drip all you want, but no water is getting into waste. It really has no impact.

So although we do have refluxing, there is sort of the effect of refluxing, because it occurs early on, is when it's most dominant, that's when the waste packages are intact. So other than initially failed containers, that really has very little impact on release.

DR. HORNBERGER: No effect on humidity, then.

MR. McCARTIN: Our humidity calculation is based on a conduction-only temperature model. So there is not. We've looked at that. We don't believe that's that big of an impact in terms of time that the humidity would change in a broad sense. It isn't impacted significantly by that, we don't believe.

However, this is one of the areas that we certainly are looking at to improve our model to try to understand -- to incorporate dripping onto the waste container and how it will affect the corrosion of that waste container. It is a limitation. We are looking to improve that. It's uncertain whether we will be able to do that by

our version 3.2, which would be for the VA, but we are starting that work and obviously that's also done in connection with the movement to a new container type, which is C-22. This model is based on 625.

So there is a lot of work. There is an area where I would say, once again, the integration between PA and the KTIs, where it's sort of growing pains, if you will. We initially put in reflux, but the fact that the corrosion model doesn't account for dripping, yes, we have dripping early on, should it impact the corrosion. We need to incorporate that, we're working with that, but, also, there is a complexity of switching from 625 to C-22. We'll see how important that is.

Then, of course, one of the biggies is actually incident on the drift. We do have an average infiltration for a sub-area. The question is how much water gets to the drift, and there's sort of a mechanism we have for focusing or spreading out of flow lines, and it's a capture area. And basically this particular factor is multiplying the cross-sectional area normal to the flow of a waste package. Obviously, if it's -- it's between .01 and three. When it's one, you can sort of think of that as everything's steady and uniform downward.

As it gets larger for a particular waste package, there is a sort of capturing, hence the name capture area,

of the flow funneling, if you will, to the waste package. So we're getting more infiltration to the particular waste package.

As it's less, then we're getting less. There is not a -- this is one of those assumptions that there is a lot of heterogeneity in a sub-area. Having a uniform infiltration, some areas are a little wetter, some areas aren't, et cetera. We're trying to capture some of that heterogeneity that we wouldn't expect a uniform blanket of moisture moving down through the mountain.

Also, in connection with that, there is also the fraction of area with dripping fractures. That simple is between zero and one. These are coordinated parameters to try to get a sense with the properties of the rock and the infiltration rates. As it gets wetter and wetter, we would expect the sub-area wet fraction, or there is dripping over most of the containers.

As the infiltration is less, you would expect there isn't a lot of dripping at the waste containers. While these are simple parameters to put in, the basis behind them is fairly complex.

The main reason they're here is to try to get a sense how important are these parameters. We know we're not capturing the true heterogeneity of the mountain, but does it make a big difference. And depending on how important

that is to the results, we want to do a better job of trying to estimate these.

One of the things I think we were pleased to see is in the DOE analyses, they were doing -- trying to relate the results of their model of water getting into drifts with some of the niche studies. We think that's a very important aspect to try to get at what are you seeing in the field and get that into the code.

I think it's useful and important for DOE to do that. Here, obviously, we don't have the kind of money to do those kinds of studies, but we were trying to assess how important is it.

That's probably a good example of one of -- why -- is that acceptable to bring in for a license application, just having this -- a couple factors there. Well, you would need a lot of support for that. We don't have that support for those parameters. I don't believe the NRC should be getting the support for those parameters.

But whatever conceptual model the DOE would have for water getting into drifts, they would have to support to a greater extent.

In terms of -- to just make it a little clearer in terms of the infiltration rate, this is, say, at least with time, you can see this is present out to 50,000 years, then to 100,000. You can see the glacial -- this is sort of the

glacial cycle we're representing in the code. Here is precipitation. You can see while we're starting on the order of -- this is sort of a representative curve. It is sampled, so it varies with each simulation, but on the order of five to ten millimeters per year. You can see it's going up into the 70-80 millimeters per year. So it is a fairly significant increase in the infiltration at later times, on the order of -- you know, it's starting to climb in the 20,000-year range, it's getting maybe twice, double what the present infiltration is.

What we're doing is we have precipitation and evaporation. We're accounting for that to get some mean annual infiltration.

DR. HORNBERGER: Tim, were all your curves flat for the first 10,000 years?

MR. McCARTIN: Actually, they actually dip a little bit for the first 10,000. In general, what you see is that in about 10,000 years, you're back to current conditions, in general. It actually is a slight dip. It actually gets a little drier. We haven't bottomed out in terms of the dryness for the curve we're looking at.

MR. CAMPBELL: Tim, is that based upon the Molinkovich site, that general curve?

MR. McCARTIN: Yes.

MR. CAMPBELL: If there was early -- is there a

sensitivity study done along the line where you look at the possibility of a much wetter climate in a shorter period of time?

MR. McCARTIN: Currently no, other than we've done some analyses to 10,000 and then analyses beyond. Obviously, a 50,000-year analysis will get the peak and you could compare the doses from the two.

MR. CAMPBELL: I'm just wondering, at the higher flux of water early on --

MR. McCARTIN: If it came earlier on, yes.

MR. CAMPBELL: -- corrosion of waste packages.

MR. CODELL: This is Richard Codell. I think this will come out in the course of events, because we sample larger values of infiltration. Although we're not explicitly looking at a wetter climate, in just the normal sampling, you would see the effect of the wetter climate.

MR. McCARTIN: Right. Although -- well, not in terms of corrosion of the waste package, though, because it's conduction only. I mean, that part of the release. We're looking to better understand would dripping on the waste container change the corrosion rate significantly.

With 625, we weren't as worried because the pitting corrosion was occurring in the two to 5,000-year range. With the C-22 going much further, we may need to -- well, we are looking at that to understand that better, but

it's -- in terms of that part of it, I don't think it would make any difference earlier on in terms of the corrosion. But more water clearly produces more releases.

So the waste package degradation, when it fails, what type of failure, and how much water enters the waste package, there a couple ways the package fails. The waste package corrodes. We're looking at the temperature, humidity and the chemistry at the surface of the waste package to do that -- to select the right corrosion model, be it dry oxidation, aqueous corrosion.

We are using a representative container in the sub-area for determining the corrosion of container, such that when that one container corrodes through, all the containers that haven't failed by other means in that sub-area are assumed to be failed. We have thought about a better way to do that and what it means. Depending on when things fail, if the failure time, once again, for 625, the failure time, if it was short enough between the first and the last container due to various conditions, it wouldn't be that big a deal.

However, with C-22, we're still looking at that model that's uniform corrosion. We have thought about this. It becomes very -- one of the dilemmas is do you try to represent all the containers, and clearly that's not possible. But we are looking at approaches for maybe

looking at a finer set than just one per sub-area.

Critical relative humidity for aqueous corrosion to occur is sampled between 75 and 85 percent for humidity. When the humidity is at that range, we are going into an aqeous corrosion environment.

We also have mechanical disruption of the waste package. There is fracture of the outer overpack due to the thermal embrittlement. There is direct disruption due to faulting and igneous activity and there is rupture due to rock faults and due to seismicity, and we account for all of those when the disruptive events are turned on.

We also have initially failed packages. Once again, here's a parameter range that there was some looking at properties of other types of manufacturing processes to get some number that might be representative of a high level waste container. There wasn't a lot of work, but the question was one of does it make a difference if you have a small percentage of the packages fails early on due to -- be it a manufacturing defect or damage during emplacement, and you can see we have basically a 100th of a percent to one percent.

It's one of those things, did it make a big difference to performance. And then diversion of water. The question is one of once you have water flow at the drift, how does it get into the container, and, once again,

here is an example of where we have 625. The failure mode is anticipated to be pitting corrosion. So we have little pits. How does water get into that little pit?

We have a parameter that looks to divert water away from the container and it's due to both the diversion around the drift, that some water will come in, but go around the sides. It won't all drip onto the container.

Some of the water that drips onto the container will run off. Not all of it will go into a pit and we have basically a lognormal distribution that sampled between .01, .2, for -- that's the quantity of water that actually gets into the waste container.

CHAIRMAN GARRICK: Tim, you said something kind of interesting that maybe this sub-area division approach you're taking will accommodate the consideration of a graded failure process of the waste packages.

The sub-areas, as you indicated earlier, were established on the basis of natural setting issues and temperature and what have you, not on trying to do this.

Do you --

MR. McCARTIN: Well, the code does accommodate -- I mean, we aren't limited to seven sub-areas. We can have more sub-areas if we would like. The question would be, it may not be prudent to go to more sub-areas from the stream tube standpoint, but in terms of breaking -- looking at a

particular sub-area, can we break it down to finer disparitization to account for some of the heterogeneity in the temperature, possibly water flow and humidity, et cetera, would it make a big difference in terms of if the failure is spread out over a longer time.

Now, part of that -- I would say computationally, you keep adding more and more complexity to the code, it gets slower and slower. We initially want to look at that from the standpoint of will it make a big difference, before we incorporate it, and we're looking at that issue.

Part of it is tied to -- let's say, for example, if I had a 5,000-year -- a mean, if I accounted for some of the heterogeneity in characteristics of containers, as well as the near-field conditions, and my mean lifetime is 5,000 years and maybe it only -- the variances maybe 4,500 to 5,500 years, I would argue that it probably isn't worth trying to simulate that.

If it's much different, as the differences grow in terms of the earliest versus the last, it may be worth accounting for that. And the other dilemma is, once again, with 625, we felt that the range was fairly narrow. With C-22, I don't want to commit to knowing what that is. We're still looking at how to improve the models for C-22.

CHAIRMAN GARRICK: Yes. It may turn out with C-22 that what becomes critically important is the whole quality

control of the fabrication, because if it turns out that C-22 can perform like the first readings are indicating, then it seems to be much more a matter of the integrity of the package itself.

MR. McCARTIN: Right. I agree. For example, right now, our model is dependent, for 625, to temperature and humidity. Variation in that will affect the time it corrodes.

For C-22, it may be much less sensitive to that and, therefore, maybe I wouldn't want to go to a finer disparitization. I just don't know and that's -- certainly one of the big areas, if you look at it, has the integration of PA in the KTIs. I think there is a very strong message to the container people that we really need to understand the behavior in the performance of C-22 much better. And they certainly agree with us whole-heartedly and I think that's a good cooperation.

Also, the near-field people, trying to understand what is the relationship of the conditions we expect to see relative to what makes C-22 vulnerable. That's all very new activity and clearly that was not incorporated into this version of the code.

As you know, our waste package, we've told you before, is a bathtub type model. Once again, that's something we're looking at with 625, where the dominant

failure mode was pitting corrosion versus if C-22 is uniform corrosion, that's something we're looking at to see whether this model is still appropriate.

We do have the ability to do a flow-through model, which is a very low bathtub, if you will. But for now, water goes in, in one pit, and there is some other pit at some lower depth, the water has to rise to that level and then it goes out.

In terms of the release, what rate are radionuclides leaving the EBS, and, in general, once again, it's probably worth pointing out that we're looking at release from the container. We aren't accounting for any hold-up in the backfill or in looking at the inve ., et cetera, at this particular time. We're looking at approaches to maybe account for transport through that part of the EBS. But for now, when it gets out of the container, it does get to the unsaturated zone immediately.

We're looking at the chemistry of the water contacting the waste form. We also look at the surface area of the waste form contacted by the water. Our bathtub model, we have a uniform distribution between zero and one as the height of that outlet point.

So you can see when the outlet is very low, at the low end of the range, the bathtub fills up very quick and releases occur early on. However, there isn't a lot of fuel

that's submerged. The surface area of the fuel that's wetted is lower because of that.

Conversely, when the bathtub is up near the top, it takes a while for the bathtub to fill up. Sometimes, at the flow rates we're talking, on the order of 1,000 or 2,000 years to fill up. But when it fills up and releases, there is a lot of fuel that's wetted.

So there is -- we have sampled that parameter to try to get a sense and it is important how much of the surface area is wetted.

We have release rates and solubility limits. Finally, we -- to get the total release, we have obviously different failure models. We have containers that fail due to corrosion, containers that fail due to the embrittlement and the fracturing, containers that fail due to the scenarios such as faulting, volcanism, et cetera. We sum up all the ones that are wet. Once again, that sub-area wet fraction that I talked about before, the only containers that can release are the ones that actually get wet.

Unsaturated zone transport, once we get to the -- get out of the container, we're into the unsaturated zone. We're accounting for the -- the sub-areas account for the spatial distribution of the flow and as I noted, the climate change accounts for tempo variation in flow over the seven sub-areas.

There is also the fracture versus matrix flow. That's done on a per-unit basis. There's -- for each of those sub-areas, they have their own individual stratigraphy between the saturated zone and the repository.

We look at the hydraulic properties and the percolation rate to determine whether we have fracture versus matrix flow. Here is one area where we simplified our model versus IPA phase two. In IPA phase two, we tried to account for both matrix and fracture flow. In this particular model -- well, when we went to this latest version, we noted that that really didn't have that strong an influence, that there were units that were primarily fracture all the time or primarily matrix all the time.

So we just looked at that and it's either fracture all the time or matrix all the time. We aren't looking at partitioning that.

That does tend to be a little conservative for some units if you are close to the -- just a little bit over the matrix conductivity, it would be all fracture flow.

One of the differences between some of the DOE modeling and ours is what's going on inside the fractures. Basically, the retardation along the transport path. We have considered matrix infusion and sorption on fracture surfaces to not be very significant in the unsaturated zone. So we have conservatively assumed them to not occur.

We have no matrix diffusion in the unsaturated zone and we have no retardation fractures in the unsaturated zone fractures.

However, there is a Calico Hills vitric unit which has an extremely high matrix conductivity. So it will always be matrix flow. There will be sorption for a number of the radionuclides in the Calico Hills vitric and I would say that's one area that there was a slight difference between the way we represented the stratigraphy in the unsaturated zone and what DOE did at the last technical exchange, and they have the Calico Hills vitric in more of the sub-areas than we have.

That is certainly a difference. For the radionuclides that are retarded, that is a difference between the two. We certainly will be looking at that and trying to incorporate some of that. But once again, I guess I would always like to point out that we would expect DOE to have a better characterization of the unsaturated zone and the saturated zone at Yucca Mountain than we would have and we certainly look to what they're doing, assess their numbers and try to incorporate that.

But at this particular time, certainly in terms of a difference in results, that would show up. Just to -- I'll just talk to these very briefly to make the point in terms of -- say, for the Topapah Springs welded unit, you

can see the conductivity for the matrix varies between 6,000-thousandths and six-tenths of a millimeter per year.

Well, it's easy to see that when we're varying our initial infiltration from one to ten millimeters per year, that, in general, we should have fracture flow just about all the time, and that's one of -- that's a unit where we feel fairly comfortable with the modeling approach we have.

The Calico Hills vitric unit, as I mentioned, its conductivity in the matrix varies from 600 to 60,000 millimeters per year. With the infiltrations that we're looking at, it's pretty easy to see that that will always be matrix flow.

Some of the other units, the zeolitic, these numbers actually changed and the more recent data made them a little higher than what we had in our TPA calculations in phase two. So this one, it is -- partitioning that would tend to be a little more conservative in the units where those are present. And we are looking to revise these values and it may be worthwhile trying to partition some in those particular layers.

But in terms of the stratigraphy, as I noted, the Calico Hills vitric is the unit with the highest matrix conductivity. It would have matrix flow and the sorption that would with matrix flow. And you can see, for our sub-areas, there's really only two sub-areas that have that

particular unit.

DOE had it, although they aren't necessarily very thick in those -- in some of these sub-areas, but they had the Calico Hills vitric in more area-wise, more area than we did for our particular calculation. That's something we'll be looking at to see if -- to take into account their later stratigraphy.

The one thing that I guess to temper that, though, in terms of the -- just slightly in terms of the retardations, some of the nuclides that we're most interested in are the ones that aren't that retarded. So it's sort of -- it's sort of a little hold-up a lot of things, but things like neptunium tend not to be very retarded, and that does -- accounting for a little bit of retardation of neptunium doesn't necessarily buy you a lot.

In the saturated zone, we have the seven sub-areas connect into four saturated zone paths and as I mentioned, we have really two units. One is the fracture tuff, approximately 13 kilometers, and then alluvium the rest of the way to the receptor location. And in our model, our transverse dispersion is neglected. We are accounting for longitudinal dispersion, although the stream lines of our flow paths do go wider and narrower and we do account for that spreading of the stream lines, if you will.

In the fractured tuff, we are assuming the

transport is only in the fractures. We do have matrix diffusion. We have added that to the model, with retardation in the matrix. The fracture velocities vary for our model approximately 50 to 500 meters per year.

So the fact you can see 13 kilometers with no matrix diffusion at 500 meters per year, the pulse is going to get there in 26 years, at the high end. At the low end, it's 260 years. So it gets through the tuff rather quickly without matrix diffusion.

In alluvium, it's porous flow, with the retardation associated with the alluvium, although there is a fair amount of uncertainty with the retardation values in the alluvium and we're hoping to learn more about that and encouraging DOE to explore and get measurements on the alluvium KDs.

The velocity is significantly different. We're looking at three to five meters per year. You can see an upper bound, two orders of magnitude slower than the fractured tuff. Retardation factors, neptunium, we're looking at one to 320; technetium, one to 33; thorium, some of the ones that are retarded quite a bit more, 1,600 to 32,000. So you can see for some nuclides, you have significant retardation that are going to hold it up quite a bit. Neptunium, technetium, still at the low end, we're looking at them unretarded.

Just briefly, to give a sense of -- I got things to the receptor location, but before looking at those, I just very briefly, in terms of the disruptive events which are affecting the container lifetime. Faulting, we have faulting event with -- the time of which occurs with a finite exponential distribution between 110,000 years, recurrence probability of ten-to-the-minus-five per year.

What does it all mean? Well, in general, when we sample, it's going to be sampled -- you know, it will look almost uniform between that distribution of when it occurs.

There is a fault length, a width, to determine a -- just from a geometric argument, through the repository and depending on its area, we're assuming a uniform distribution of containers. That's how many containers are failed, given there is a certain displacement.

It's just based on a displacement argument. If the displacement is at least X when it's sampled, it will be failed because the containers in that area will be failed.

Seismicity due to rock fall and at the technical exchange, we were still in the midst of revising some of this and I can point to one of the changes from that, but, once again, we have recurrence rate of certain seismic events.

Up here, the question is what's the rock stability type. We have five different rock types, but you can see

type four covers approximately 63 percent of the repository, type five covers approximately 36 percent of the repository footprint. So it's really type four and type five that are going to dominate the effects of the seismic event.

There is a joint spacing. Rock type four is .63 meters, five is .36, and there's a column height calculated depending on the particular event, be it a .1g versus .2, et cetera. You have a different column height. There is a weight that falls on the container. There is a calculation done based on the ultimate strength of the container to determine whether the container is damaged.

One of the things, and this is a model we're also looking at to improve both the model for the -- based on rock mechanics and the model for the ultimate strength that we're using for damaging the container.

So we do anticipate further improvements in 3.2, but one of the simplifications that we have is that -- let's say you have the, whatever, a seismic event and you have rock type four. Do all containers -- do all containers experience a rock fall, and the question is no. There are some -- some do, some don't.

This heterogeneity factor is multiplying how much of that area would experience rock fall, and this right now is sort of one of those parameters that is an educated guess based upon the people involved in the work, the engineers

and the geologists, trying to capture how much of the sub-area would fail due to a seismic event.

CHAIRMAN GARRICK: Just to push you a little bit on this, Tim. Based on what you all now know, what is your assessment of this as an issue?

MR. McCARTIN: Well, in terms of the way it currently is modeled in terms of the number of containers it affects, it's a relatively small number for 625. We're looking on the order of a few percent of the containers, in general, in general. So it's not very big.

The question that we now have, and it's kind of a -- you know, this is one of those areas where we're right in the middle and you also caught us in terms of changing material types, which is a very difficult thing.

Now, for 625, we had a very simple model that was conservative. However, the -- we were looking at pitting corrosion resulting in a failure of the container in the -- I'll say roughly the two to 5,000 range for a large number of the containers. So we weren't overly worried by the seismic event because the containers were already failed due to corrosion.

Now we're stepping back and with the addition of C-22 and the prospect of a container lasting much longer. Well, the conservatism we had for a rock fall is maybe too conservative for -- now that the container lasts much longer

and we need to improve it.

Right now, though, it isn't dominant in terms of the effect of the results, but part of that is due to the fact that the corrosion was occurring at an earlier time. But that's one of the areas that we're looking to try to get a better sense of how the models here should be improved for something like C-22.

Jim, you want to add something?

MR. FIRTH: James Firth, NRC. Another aspect of moving to C-22 that's not covered in how we've modeled rock fall in the past is it could cause accelerated corrosion and anything that could cause accelerated corrosion and earlier failures for a very long-lived waste package could be more important in a relative sense.

So that's not something that's not in our model, but is something that we're having to look at.

CHAIRMAN GARRICK: Accelerated corrosion as a result of deformation or --

MR. FIRTH: Adding stresses to the waste package and possibly also finishing off the outer waste package earlier.

CHAIRMAN GARRICK: Thank you.

MR. McCARTIN: However, I'll say we're not anticipating it to be a big problem, but as the corrosion makes the containers last a lot longer, you want to make

sure you're doing a good job on the other kinds of things that could fail the container.

CHAIRMAN GARRICK: You also want to make sure that when something like this pops up and that there's a possibility to make an easy fix, that that's considered sooner rather than later. That's, of course, a DOE problem. Charles, you had a question.

DR. FAIRHURST: I was just wondering. What do you mean by type four and type five? Is that a definition of fracture frequency or something?

MR. McCARTIN: That's way -- I'll have to ask for someone in the audience. But it's basically different rock types and it has to do with the properties of the rock.

MR. FIRTH: James Firth, NRC. The way the rock was divided was based on the joint spacing in the rock. So it was categorized into five different categories and that paralleled what DOE was finding in terms of characterizing the ESF.

DR. FAIRHURST: I don't want to get too deeply into this, but if you have a type four rock, type five is a more frequent fracture, right?

MR. McCARTIN: Yes.

DR. FAIRHURST: Do you assume the same volume to fall out and if so, do you assume that it's as a single mass or is it a broken up to have little impact?

MR. FIRTH: The way it has been modeled is the area of the rock falling on the waste package is going to be the square of the joint spacing and then the height of the rock could be as high as the yield zone based on some UDEC runs in terms of the thermal stability of the drift.

DR. FAIRHURST: But then do you assume that that comes down as a single block?

MR. FIRTH: At this time, yes.

MR. McCARTIN: Or if not a single block, a single weight. It's coming down at once and whether there's a -- it could be -- that column of rock could be fractured in between, but if it's all coming down at once, the weight is the same.

DR. FAIRHURST: The weight is the same, but the impact is going to be quite different. Maximum stresses induced in the canister will not be the same.

MR. McCARTIN: Okay. Well, we're certainly looking to improve -- we recognize the limitations and simplifications both for the way we've characterized the rock fall and the way it damages the waste container. We're looking to improve that a little better just because we expect the container -- before corrosion was going to overtake it soon enough that it wasn't a big deal.

Now, with corrosion, and we have to do a better job.

CHAIRMAN GARRICK: Just one more question, Tim. Are you aware if DOE is, in their attempts to design out this problem, for example, are looking at both the engineered barrier approaches and tunnel design considerations for doing that?

MR. McCARTIN: In terms of precluding rock fall?

CHAIRMAN GARRICK: Right.

MR. McCARTIN: Backfill would preclude the rock fall. I mean, that would be the simplest fix in terms of -- I'm not aware of anything in terms of designing the tunnel to prevent it. The biggest problem would be just the time element. Once you get a couple thousand years from present, what design you would do, but I'm not aware of anything.

But I will say that's not my -- rock mechanics is not my specialty, by any means.

CHAIRMAN GARRICK: According to one of our esteemed members here, there are some things that you evidently can do with the natural setting that could have a significant impact on this and I was just curious if DOE was considering that in addition to -- I know they're talking about fillers and what have you and barriers and backfill.

MR. McCARTIN: I do know that -- I believe at the TRB, they are going to talk about their approach for seismically-induced rock fall. So the fact that they're doing it in their PA calculation, I would assume that there

would be some feedback to repository design. But other than that, I'm not aware of anything explicit.

In terms of the direct release, the volcanic event, the extrusive component, there's entrainment of the spent fuel in the ash and it's basically based on, once again, similar to what's done for faulting, a geometric argument, how big is the volcanic conduit relative to an average number of waste containers per unit area.

In general, you will see one to ten waste packages affected by an extrusive volcanic event. There are certain parameters to incorporate -- have incorporation ratio of the spent fuel into the ash.

It certainly is affected by the spent fuel particle size, which is a difficult thing; what is the particle size of the spent fuel when this volcanic event comes in.

You then have the air transport of ash and deposition of -- at the receptor location, once again, particle size affects that. You have the wind speed and direction and the eruption energetics. Probability of the volcanic event, once again, we have a time of the igneous event. Similar to faulting, it's a finite exponential, with a very low recurrence probability.

It somewhat ends up that this becomes a uniform distribution. It samples uniformly between those time

periods.

CHAIRMAN GARRICK: You better move on as quickly as you can, Tim.

MR. McCARTIN: Okay. Has it been 40 minutes? I'm close to done. The dose calculation, we're looking at dilution of radionuclides in the groundwater. We're looking at the pumping well characteristics and water use. Right now we're looking at the Amergosa -- 20 kilometer Amergosa Farms kind of environment, where you have farming and we're looking at a fairly large pumping rate, consistent with farming in the area.

We're looking at dilution of radionuclides in the soil, plowing and surficial processes. That's primarily from the direct release. There is a mass loading factor for the air pathway, which is the dominant parameter for determining the dose, how much stuff gets up in the air that is then available for an inhalation.

And those conversion factors we are looking at lifestyle, diet of locally grown food, and we're using a representative person. We don't calculate doses to a lot of people and average them. We're looking at a representative person and doing a single dose calculation and we're certainly using a reference biosphere and cautious and reasonable assumptions, we believe.

In summary, we certainly have -- the TPA 3.1 code

is being used to look at different aspects of repository performance, like the stresses development is iterative. We believe there's a lot of flexibility to analyze a lot of different situations and I think you will see that in Dick Codell's and Jim Firth's presentations; in the sensitivity analyses, where people have looked at performance in a lot of different ways.

Input and parameters, we have a TPA input file that's 2,000 lines, organized by module. It actually is a fairly easy input file, I think, to read through to see what the parameters are. We are going to document the input file with conceptual models and the sensitivity results. We hope to do that in the late summer.

We always like to include our caution, of course, and then what you're going to see next is Sitakanta Mohanty from the center will present the results of the total system analysis with the scenarios for the reference case. Then Jim Firth will present the sensitivity analyses at the process level, where KTIs were calculating for a particular module or a particular process and looking at the sensitivity of their module, their process.

Then finally Dick Codell will present the system level calculations in terms of the total system analysis where we varied all the parameters, including alternative conceptual models.

Let me stop there. I think there is one last slide, but I can -- in the interest of time, I'll forego the one.

CHAIRMAN GARRICK: All right. Do you want to ask some questions now or wait a while? We have a break scheduled for now and I think we'll take it. I think, also, I would like to comment to the staff that it's my understanding that there is some cooperation between this presentation and the viability assessment presentation to get the material in that you desire.

The only thing I would ask and encourage you to do is to do the planning such that we do finish the viability assessment guidance presentation by 3:00. That has to be -- okay.

With that, I think we'll take a 15-minute break.

[Recess.]

MR. McCONNELL: Keith McConnell, again, from the NRC staff. The next speaker or presenter is Sitakanta Mohanty, from the Center for Nuclear Regulatory Analyses. The center and the NRC staff work closely together on the development of the code, as well as the conduct of the sensitivity study.

Sitakanta will be talking about the nominal case and some of the selected scenario outputs.

MR. MOHANTY: As Keith pointed out, my

presentation is the use of total system performance assessment, called version 3.1; to be more specific, 3.1.4. I will be presenting to you the results from a nominal case and selected scenario outputs.

The objective of this presentation would be twofold. First is to outline the main outputs from the TPA 3.1.4 code using a referenced data set and also to present some intermediate outputs from which we gain some insight into the code. Another input or function alternative outputs to give us some feel for the correctness of our computation.

To briefly present various modules in the TPA code, here is a flow diagram. Essentially, it has two parts. The base case part and the disruptive scenarios. The disruptive scenarios along with base case we'll consider our reference case. The boxes along this line represent the base case. That include the precipitation history for the infiltration, then the shallow and deep, near-field environment surrounding the waste package inside the repository, followed by the computation of waste package failure due to corrosion, then the radionuclides released from the engineered barrier system and subsequent transport in unsaturated and saturated zone, and final computation of those individuals.

When we combine with faulting displacement,

seismic rock fall and igneous activity events, that would constitute the reference case. The faulting displacement and seismic event will contribute to additional failure of these packages and the computation is for groundwater release and subsequent dose, whereas the igneous event would contribute to direct release of the radionuclides for ground surface dose.

Here I should point out that by the nominal case, we imply that the seismic rock fall is combined with a base case because the seismic rock fall at this point we consider that as contributing to the natural evolution of the repository.

In the set of calculations, first we determine the shallow and deep percolation. The shallow and deep percolation are heavily influenced by the climatic events.

The infiltration, the solid infiltration is computed as a function of climate change, soil depth and soil hydraulic properties. As Tim pointed out, we do not take into consideration surface runoff and transpiration, but evaporation is taken into consideration.

In this diagram, we are presenting the average rate of infiltration in millimeters per year as a function of time. Here we are presenting the results to 50,000 years. As he pointed out earlier, this infiltration does not change very much up to about 10,000 years, but it's

subsequently included because of a glacial period.

In our computation, the switch from the current climatic condition to glacial climatic condition takes place somewhere around 12,000 years.

This infiltration rate is later on modified for determining how much radionuclide is going to leave the EBS. This infiltration rate is used for the unsaturated zone and transport calculations.

Once we determine how much water can potentially get into -- get near the repository, then we compute the temperature and the relative humidity that is subsequently used in the computation of waste package failure. In addition to that, the temperature reviews to determine how the incoming water -- from now on we will call that isothermal infiltration -- is subsequently moved because of the heat generated from the disposed waste.

In this particular -- in the best case, we consider that no backfill is present, because that is the reference design at this point, and the relative humidity is calculated by taking into consideration the temperature of the waste package surface and the temperature of the drift wall.

In this figure, we have presented temperature and relative humidity. As temperature goes down as a function of time, the relatively humidity goes up and subsequently

becomes one, once the repository cools down.

DR. HORNBERGER: Sitakanta, could I ask you a question while you're here? I realize I'm anticipating, but I know later you're going to show us a figure where we see a significant fraction of the waste packages failing early on in this first few thousand years. Is it because this figure you have relatively warm and wet conditions from about the year 1,000 to 7,000 or something?

MR. MOHANTY: That is primarily the reason, but I can say more about the temperature than the relatively humidity because the relative humidity, the critical relative humidity, we are using that as a criterion for the failure. But, yes, the temperature has a significant impact.

Now that we know that isothermal infiltration and we know the temperature in the near field of the repository, then we compute how much of that isothermal infiltration which is represented by the red curve is modified because of the reflux. I want to point out that the reflux takes place in about 100 meters about the repository, within a 100 meters of the repository horizon.

In this figure, it is evident that most of the reflux is taking place in about two to 3,000 years. In other words, as the temperature comes down, the reflux approaches, by isothermal infiltration, and after that they

would be the same infiltration.

In this particular calculation, we have chosen the rise and fall reflux conceptual model. That is one of two models we have. In one case, we are relying on the amount of water that is driven out of the matrix. In the other one, we essentially rely on how the reflux takes place in the fracture.

This information is used for the radionuclide release calculations, as Tim pointed out. We are only taking relative humidity into consideration for the waste package degradation.

By showing this figure, I would like to make a clear distinction that once the water is refluxed, it does not necessarily get into the waste package, nearby the waste package right away. That water is modified, as Tim pointed out, because of the heterogeneity outside of the drift.

So this modification protect us because of the heterogeneity of the fracture, so flow could focus. It could also divert. Also, it depends on the presence or absence of backfill and pits. If it is a pitting type of corrosion, then pits will allow only certain limited amount of water to get into the waste package.

Also, these factors do not change as a function of time. By using this factor, we also determined how many waste packages got weight and amount of water that was

coming as a blanket, as Tim pointed out, that may have focused into only a few waste packages.

In this particular case, we are presenting infiltration as a function of time. If this one represents the amount of water that comes in after the reflux, this represents the amount of water that truly gets into the waste package. So it is much less than that.

So the difference between these two curves would be a combination of these factors, but of the constant, because it doesn't vary as a function of time.

DR. FAIRHURST: Excuse me. Is the reflux something that's happening all the time or is it something that's predominant only during the thermal cycle?

MR. MOHANTY: It's predominantly in the thermal cycle. That's why the --

DR. FAIRHURST: The thermal cycle is finished fairly early, right?

MR. MOHANTY: Fairly early, within about two to 3,000 years. That's how the graph is showing now, the current calculation.

So now that we know the temperature and relative humidity, we also use externally computed chloride concentration and other chemistry, near-field chemistry and related parameters to determine waste package failure.

In our nominal case calculation, we are using

carbon steel, A500, 16 grade, 55 outer overpack, and 625 as the inner overpack. The mechanisms that are considered in the failure are dry oxidation, uniform or localized corrosion, and mechanical failure.

In this particular graph, we are not showing any faulting or volcanic events related to waste package failures, but we have included seismic related failures because seismicity is a part of the nominal case.

Also, in the corrosion failure, especially for alloy-625 inner overpack, galvanic coupling is not taken into consideration and the importance of having no backfill is that it changes the temperature that would have been if we had the backfill present.

In this figure, I would like to clarify that frequency is nothing but the fraction of total number that contribute to a particular failure, and the distribution of failure time. So this column represents that nearly 18 to 19 percent of the waste packages -- 18 to 19 percent of the time, out of 400, the corrosion-related failure or seismic-related failure took place a around 2,000 years.

Once we have computed number of waste packages that have been affected by corrosion and seismic failure, then we compute the water that gets into the waste package and the subsequent release.

For the base case or the nominal case, we are

considering the bathtub model and in the bathtub, the release is congruent or the dissolution is congruent for the spent fuel. Out of the three dissolution models, we are using the one that has dependency on calcium silicate and the pits that we talked about earlier for determining amount of water that gets into the waste package, do not offer any flow resistance because of its size. We do not take any credit for the cladding because we are not sure what is the right number.

Also, DOE, at this point, is considering not to take any credit for cladding. Here, again, we are presenting a frequency like the previous diagram, except that here we are presenting the peak release time. One thing to note here is that for a particular nuclide that we have chosen here, technetium-99, the peak release time approximately coincides with the failure time.

That is why we are seeing this bi-modal distribution and one thing I should have pointed out earlier is that this bi-modal is coming from the localized corrosion effect and uniform corrosion effect. The uniform corrosion effect has given rise to much longer failure time.

Responding to that, we have presented here the peak release in curies per year and these are the CCDF curves for various sub-areas and the important thing to note here is that this variation amongst sub-areas is coming from

the number of waste packages that are present in the sub-areas. In other words, they are directly related to the size of the sub-areas.

CHAIRMAN GARRICK: So these release rates are from the region of the engineered barrier system. This is the source term.

MR. MOHANTY: Yes, that is correct.

Here is another way for presenting the results. In this particular figure, which has three CCDFs, are cumulative release at the end of 50,000 years. That includes the cumulative release just outside the waste package, outside EBS and just outside the unsaturated zone and just outside of the saturated zone.

As Tim pointed out, in the unsaturated zone, there is no matrix retardation and no matrix diffusion. I would like to correct this word, this should be diffusion.

And for the saturated zone flow and transport, we have fracture tuff and alluvium and the matrix diffusion option is there, but we have it turned off in this particular calculation. The receptor group is located at 20 kilometers.

One thing to note here is that although we have three curves, we see only two. That is because the unsaturated zone, accumulated releases from the unsaturated zone are very similar to that of what we get from the EBS.

However, this highlights that certain retardation of time difference taking place for the cumulative release because of the saturated zone.

To give you some idea about how fast the nuclides or the water is traveling -- not nuclides -- that carries the nuclides, here are two CCDFs. The upper one is representing the unsaturated zone and the lower one is representing -- the bottom one is representing the travel time CCDF for the sat zone.

As I pointed out, the receptor group is located 20 kilometers away and the similar thing is to 50,000 years. Here we have presented results for seven sub-areas and this dotted line represents the average groundwater travel time for the whole repository and this is approximately a 1,000 years here travel time.

Here is a similar one for the saturated zone. We saw that for a 20 kilometer distance. The average groundwater travel time is about 4,000 years.

Another point I would like to make here is that in the unsaturated zone, sub-areas one, two, three and four, less travel time than five and six. This is because in five and six, the flow is controlled by the matrix flow, as Tim pointed out earlier. But in this case, the flow is essentially fracture flow.

Then we compute the groundwater dose and the

receptor group is located 20 kilometers away. Again, the computation is for 50,000 years. And here we are showing various CCDFs for individual nuclides and this figure shows outputs from 400 realizations out of 20 groundwater nuclide studies we are considering, we are presenting here the top seven to eight nuclides.

This dotted line represents the total of all nuclides and in comparison to the total, these CCDFs present a big dose for the top seven nuclides; that would be neptunium-237, americium-243, and thorium-245, likewise.

So in essence, we saw a big variation in terms of the dose contribution and the mean peak groundwater dose is 14 milligrams for a year. That's what our preliminary calculation is suggesting.

Now we do a comparison between the 10,000-year one versus the 50,000-year one for the peak annual dose, and these are two CCDFs. This represents 10,000 years and this represents the 50,000-year peak dose.

Just to point out, again, that seismic event is taken into consideration in representing this peak dose curve. For 10,000 years, we get 1.7 millirem per year, whereas for 50,000 years we get about 14 millirem per year.

DR. FAIRHURST: Have you made any attempt to go beyond 50,000 years to see if that continues to rise?

MR. MOHANTY: It may rise. We have not done any

of our final runs for beyond 50,000 years. I do not know if Dick Codell may have done some. If he has, he will present it.

DR. FAIRHURST: Because one of the Academy's concerns in the Yucca Mountain report was that the dose was going to keep rising over quite significantly longer periods. So it's something that will be raised as an issue, I think.

MR. McCARTIN: Although in general, our peak dose is typical of neptunium and there are certainly in the 50,000-year time-frame. It isn't that retarded. So there are certainly some of the realizations represent the peak. In general, obviously, until you do the long-term calculation, you're not certain, but we do not expect the doses to get much larger.

CHAIRMAN GARRICK: I guess also when the Academy was first looking at this, they were talking about much smaller percolation fluxes and lower infiltration rates and the peak -- evidently the peak goes out into the hundreds of thousands of years.

MR. McCARTIN: And one thing to add, I mean, one of the reasons will -- certainly we would expect to see doses increase to 50,000 years is, if you remember the climate change. Infiltration is increasing as it continues to increase. It's not too surprising that we would expect

to see, as we're getting wetter and wetter conditions, it to increase.

CHAIRMAN GARRICK: I'm curious as to whether or not these analyses have revealed any surprises to you. I didn't have a chance to look at it too long, but it looked like the neptunium was still the driving radionuclide. And as the percolation fluxes increase and infiltration rates increase, there tends to be a switch between neptunium and technetium.

I didn't see that on this.

MR. McCARTIN: Neptunium, I guess, is a partial surprise. Certainly neptunium tends to be way -- very, very dominant. Now, this is at the 20 kilometer, so the alluvium is accounted for. Surprise is -- I guess I'm hesitant because we're still looking at this to see what it means and certainly what it has done has certainly got us to look at some of the release mechanisms in the source term.

With respect to neptunium, we're looking at secondary minerals as a way of do we need to be a little better on our release model for neptunium. So there's things like that.

I don't know, Dick, if you wanted to add anything, but I guess we -- you know, we would have expected a few other nuclides to show up, but neptunium is very dominant.

MR. CODELL: This is Richard Codell. The

technetium is way down really compared to neptunium and americium. It just doesn't seem to show up.

CHAIRMAN GARRICK: I understand. But as we moved away from the very low infiltration rates in some of the earlier studies done by DOE, I thought we were observing technetium coming into much more prominent position.

MR. McCARTIN: Right. And one thing that we probably need to be a little cautious on and we're sort of right in the middle of analyzing it, but one thing that we are going to look at it and one of the -- when you look at a peak annual dose, it's sort of you tamp down that dose and maybe the technetium at that time wasn't large, but maybe its peak occurred three or 4,000 years earlier and you're not seeing it and maybe it -- so you need to look at the whole spectrum of the doses, and we haven't done that as much.

And so say neptunium at whatever, 12,000 years, its peak is say 20 millirem, technetium is 18 millirem peak at 5,000 years, you don't see it.

CHAIRMAN GARRICK: Yes. I understand.

MR. McCARTIN: So there is some of that interplay that we haven't completely factored out.

MR. MOHANTY: I used to have the graph that would have shown the time during those. I do not have that with me.

CHAIRMAN GARRICK: We will eventually see it, I'm sure.

MR. MOHANTY: In this viewgraph, we present the results for 10,000 years, but here we have combined other disruptive events. In this CCDF, which is a plot of the peak annual dose versus the accident probability, we essentially have four different curves. This one is the nominal case. This curve represents the faulting CCDF, and this one represents the contribution from volcano.

And when we summed them together, then this curve is the total curve. I would like to point out that the faulting and volcano doses are combined as annual dose, but if we really want to determine the facility dose, this could be about 10,000 times -- it could be much larger than what we are presenting here as the mean annual risk.

Compared to the 10,000-year, here we have the 50,000-year, similar, and, again, this represents the faulting, this represents volcano, and this is the nominal case. That is the base case under seismicity. Under total curve, it is represented by the red one.

You will again notice that in the peak annual dose, this would be event per year, the mean risk here shows identical to what comes from the nominal case. Once again, if we determine that the facility dose, it is going to be larger than this.

In summary, we have made an attempt to present some of our outcomes, our results from TPA 3.1.4 code. And we have used a nominal case and we have shown in combination with two other disruptive events and this presentation was primarily for demonstrative purposes only, and currently further modifications are going on to move from 3.1.4 to 3.2.

At the same time, we are also modifying our reference data set as new and more better data are made available to us.

With that, I will conclude my presentation.

CHAIRMAN GARRICK: Any questions? George?

DR. HORNBERGER: Sirakanta, on the reflux, I am trying to make sure that I understand this as well as it's possible for me to understand it, anyway. As I understand it, you people -- you use a one-dimensional model. So what goes up has to come down ultimately.

MR. MOHANTY: Yes.

DR. HORNBERGER: And I understand you have your factors that displace it around the openings and whatnot.

I also understand -- I think I understood from what you said that you find that the results are not very sensitive to reflux right now because you're looking at pitting corrosion and it's only humidity driven. Is that correct, also?

MR. MOHANTY: Yes, correct. As part of the waste package degradation is concerned, we are not taking that into consideration. But as far as the release is concerned, we do have some initial failure, as Tim pointed out, varying from 100 --

DR. HORNBERGER: Right.

MR. MOHANTY: Those definitely would be affected by the reflux.

DR. HORNBERGER: By the reflux.

MR. MOHANTY: Yes.

DR. HORNBERGER: But that is just because you have more water to transport the radionuclides away, is that right?

MR. MOHANTY: Yes.

DR. HORNBERGER: And last point. So then as you go to C-22, where dripping on the canisters may be important, I am curious. Are you confident that the one-dimensional model of what goes up must come down will be adequate to study that case, as well?

MR. MOHANTY: For the reflux, is it as opposed to being diverted or --

DR. HORNBERGER: Well, the way I think about it, if I put a single heated spot in a wet rock, probably what's going to go up is going to go into a convection cell and come down not on top of the opening.

MR. MOHANTY: I agree.

DR. FAIRHURST: You say that the other effect is that as you heat up the rock, then the fractures over the opening close, offset shears. So you create preferential pathways outside.

MR. MOHANTY: In our models, we are not considering the change in fracture weight as a function of temperature. Besides, in the particular model that I presented, in that case, the amount of water that is residing in the matrix, the inside of the rock, but in the other model that is not the case. The other one is fracture only and we have some plans for the future of how we want to improve it.

And one of the considerations for that improvement is to see whether or not all the water from the matrix would come to the fracture, eventually coming into the repository.

MR. McCARTIN: If I could just supplement it with one thought. I guess the desire in the TPA code was that the one constant that we have been seeing is that when people do heater tests, things tend to get wetter and that's basically what --- early on -- and that's basically what our model is designed to do, is make things wetter earlier on, and as a simple abstraction of, gee, that's what people see, how does it impact performance.

We are looking to see how those wetter drips might

affect something like C-22. They may or may not. I mean, we need to evaluate that to see whether it's worth putting into effect.

The other part is in the TEF KTI, they are doing some very sophisticated non-isothermal hydrological modeling to get a better sense of how the repository will interact with the system and in terms of the refluxing of water.

We're keeping our eye on that, but obviously that type of detailed modeling is done off to the side. We never hope to incorporate into the PA code, but they are looking at that issue. But it's one of those things that I think -- the thing we're trying to look at is with C-22, we need a joint effort to look at, well, what's important to C-22 in terms of how it's going to degrade and making sure that the other work is coordinated to get us what we need in terms of assessing the performance.

Maybe C-22 isn't that sensitive to some of this and we can sort of move on, if you will.

DR. WYMER: I was interested in your americium results, a little surprising. I assume you assumed to try to deal with americium and I wondered what retardation mechanisms you considered.

MR. MOHANTY: I would like to pass that question on to Dick or Tim.

MR. McCARTIN: In terms of retardation --

DR. WYMER: Of the americium. I would expect some interactions with the --

MR. McCARTIN: In fractures or in -- I mean, the only -- generally, when we're in fractures, we're not assuming retardation in the alluvium.

DR. WYMER: In the alluvium is really where I would expect it.

MR. McCARTIN: Yes. Certainly we have -- I mean, I can look real quick. I don't remember what value it is. We certainly have retardation for it.

DR. WYMER: I don't need to know the real value. I just wondered if you had taken it into account.

MR. McCARTIN: Yes. Yes. For alluvium and in the Calico Hills vitric tuff, but exactly to what extent --

DR. WYMER: And it's based on experimental information, I assume.

MR. McCARTIN: As best we can, yes. Yes. There are some areas where we have extrapolated from similar radionuclides and for americium, it's one to 400,000 in the alluvium. So we have quite a range there in terms of a retardation factor.

DR. WYMER: And what did you use?

MR. McCARTIN: It's a sample. It's sampled between one, which would be totally unretarded, to 400,000. And the 400,000 would -- it's a retardation factor, so it

would reduce the transport velocity by a factor of 400,000. So generally, you could see we probably won't see --

DR. WYMER: That is what you used. Okay.

MR. McCARTIN: Yeah.

CHAIRMAN GARRICK: I should be educated by Dr. Wymer before I ask this question, but I'll ask it anyhow. In your waste package degradation model, you assumed a dry oxidation, oxidizing environment. As the waste package degrades, of course, things change as far as the chemical environment is concerned.

I just wondered if your sense is whether or not that is an important effect with respect to the degradation rate of the waste package. It certainly probably would be an important effect with respect to the transport, radionuclide transport and retardation and what have you.

You have utilized the distribution of so many things to take into account variation. You did not on this evidently and I guess my question is does it matter. One reason for not doing is you have convinced yourself it doesn't matter what the chemical environment is as a function of waste package degradation.

MR. MOHANTY: That is something we have not done as of yet, but that is a consideration for the future. But we have near-field folks here who can address that question.

MR. LESLIE: This is Bret Leslie from the NRC

staff. I think, again, this is another example where the design might influence how we thought about it. With 625, again, we're thinking about pitting and maybe we might think about more restrictive exchange with the surrounding atmosphere. Once you start going to C-22, where it's general corrosion, you might not have that restricted pathway where the reactive transport is so important for oxygen uptake.

DR. WYMER: But in any case, you have an outside steel container, regardless of what you have inside. So you still expect the --

CHAIRMAN GARRICK: So you still have a lot of iron.

DR. WYMER: A lot of reducing iron.

CHAIRMAN GARRICK: Which will change the chemical environment considerably.

DR. WYMER: Especially for neptunium, I would think.

CHAIRMAN GARRICK: Yes. That's what I was thinking of. Any other questions?

MR. AHN: Yes. I have a comment on that. Tai Ahn of NRC. Christen Stockman of Los Alamos Laboratory analyzed the oxygen concentration in partially failed containers and she did not see any depletion of oxygen due to the corrosion of container, mainly because the fast transport oxygen at

the temperature close to 90 degrees C. Especially outside the container, we don't expect any oxygen depletion at all.

In other words, once you have failed a container, you lose a substantial amount of structures, we don't expect any oxygen depletion, the dissolution rate of spent fuels.

CHAIRMAN GARRICK: Thank you. That's rather surprising considering the amount of iron that's involved here.

DR. WYMER: Because of the design, too.

CHAIRMAN GARRICK: Okay. Thank you.

MR. McCARTIN: Just to help the recorder, the last speaker from the NRC staff's name was Tai Ahn, A-h-n.

The next presenter is James Firth, who is going to summarize the results of the KTI level sensitivity studies. These sensitivity studies were actually conducted by the KTIs themselves using the TPA code in more of a self-assessment of the importance of parameters that are associated with our KTIs and sub-issues associated with our KTIs.

MR. FIRTH: Good evening. I'm James Firth. I want to put the process level sensitivity studies in context. As Keith mentioned, this is where we had each of the KTIs look at specific aspects of the model and this comes on the heels of several other NRC efforts and it has led up to our system level sensitivity studies which are

underway now.

We used the TPA 3.1.1 code in the fall of 1997 to do these analyses and we had the KTIs do the work. They have been involved in the model development. But what happened as we were doing the studies last fall is that we realized that there were some changes that we felt we needed to make before we went ahead to the system level sensitivity studies.

So we have identified some short-term modeling needs and some long-range modeling needs. The short-term modeling needs we wanted to have in place before we went ahead and did the system level sensitivity studies.

Now we're doing the system level sensitivity studies and then we should have the 3.2 version of the code available this summer.

The sensitivity studies that we did last fall marks a very big change for NRC because we have had much greater involvement of the different KTIs. They were involved from the ground up. They were involved in the model development and in doing the sensitivity studies. And this is the first chance really that they have been using the code and what we're doing is we're hoping that they will continue to use the code for their issue resolution and also looking in terms of what additional modeling we need to do for later versions of the code.

But some of the goals were to also identify the parameters with the greatest impact on the output, and this was on a module by module basis. Those that have very little impact, we set two constants. For the system level sensitivity studies, we tested the ones that were most sensitive as variables and I believe we're also checking to see, with everything varying, to just do a double-check on what we saw from the process level sensitivity studies.

Also, we evaluated different alternate conceptual models.

It's not only are we identifying what the parameter ranges need to be, but there are certain parameters that due to their sensitivity or due to awareness that we really need to get a better handle on it, because there is a lack of data, and it's sensitive, we wanted to identify what those were.

Also, we're looking at doing the studies in terms of issue resolution. We're not doing the sensitivities just for doing the sensitivity studies, but we want to feed it into preparing for reviewing the viability assessment, the license application, then do issue resolution in that context.

Again, we have done -- had six KTIs involved in the sensitivity studies and to give it a little bit of consistency, this is the mean data set. Each of the KTIs

would vary those parameters that they felt were relevant to what they were studying.

Some of the groundwater parameters were varied, a couple were held constant because of the divergent factors and the wetting factors to decree a lot of spread in the results. So what we did was we kept those at constants for the process level sensitivity studies so that it would be a little bit clearer what was coming out of the modules.

And now I want to go through and identify what came out of the process level sensitivity studies, both in terms of modeling and then in terms of issue resolution.

Container life and source term and looked at alternate conceptual models, then we're working on incorporating that into our code now. We looked at the capability of cladding on release and that's something that we also -- given its possible significance, we wanted to be able to model more effectively in the future.

Again, we're looking at the fraction of waste package wetting and how we're getting the water to the waste package.

For the near field, there are some approximations that we had in the 3.1.1 code and these did not allow us to see some sensitivity. If they become important, then we want to be able to look at those, basically in terms of effect of sementitious materials and colloidal transport.

We were saying travel times under a certain period of time set essentially to zero.

So if they're in that range where there are very short travel times, we're not going to see sensitivity. Igneous activity, we've already made a change from the recent suspension approach to a mass loading model, and that was done prior to the system level sensitivity studies.

Moving on to structural deformation and seismicity. We wanted to introduce parameters and model the fraction of weights that rocks fall causing the waste package failure, and that's something that we've incorporated now, because at the time of the process level sensitivity studies, we were assuming that rock in the entire rock type fell and hit each and every waste package within that area.

What we are also looking at doing is linking the failure criterion with corrosion effects. We do have material like C-22 where you have gradual decline in the robustness of the waste package. Then the waste packages could be more susceptible to rock fall of the same magnitude.

The thermal effects on flow, as has been mentioned before, we don't really have a connection, in part, because the refluxing water and the waste package corrosion are distinct and they are not being -- they are not linked at

this time.

Also, what's being looked at is to consolidate the two reflux models. There were two different models used in the process level sensitivity studies and it was felt that there was a need to possibly combine the two and incorporate these. But the need for this is -- or the significance of this is dependent upon getting the link between dripping and waste package corrosion, and that is also going to be determined by what we see for C-22 in terms of is dripping going to be significant in terms of causing accelerated corrosion.

For unsaturated and saturated flow, we want to look at the contaminant transports and some americium and plutonium made larger contributions in the process level sensitivity studies.

Then for container life and source term, we looked at diffusion versus the bathtub model and basically we saw it is a viable mechanism. Peak dose is sensitive to the spent fuel surface area. Since we're keeping it constant, that's something that we also want to be looking at in terms of do we need to make a change.

Cladding protection and particle sizes, wetted area, they all relate to the surface area available for release. The peak dose is sensitive to the time of waste package failure from corrosion and time of waste package

failure is also dependent on several factors. We looked at factual versus no backfill. In each case, there were times where the temperature and relative humidity conditions were such that you would have earlier failures for one versus the other.

But predominantly having backfill tended to delay waste package failure and had later releases. Also, the composition of the water contacting the waste is important for waste package failure, the release for the dose.

DR. FAIRHURST: In what ways does backfill delay failure?

MR. FIRTH: Okay. We were using a conduction-only model for temperature and from that temperature, we calculated the relative humidity. If the backfill caused later periods of time for -- or if the outer barrier failed later -- let me go back.

It's a function of temperature and relative humidity. You need very warm and humid conditions for accelerated corrosion and the pitting. In some cases, due to the parameter variation, backfill would have those wetter and hotter conditions, you would have earlier failures. But more often than not, you would have drier and hot temperatures and then the wetting would occur later.

So you don't have as long of a period of time where it is both wet and hot.

DR. HORNBERGER: I thought that you calculated your relative humidity strictly on the basis of temperature and not on whether you did or didn't actually have water there.

MR. FIRTH: The relative humidity is based on a temperature of the waste package in the drift wall. So if you -- and since it's very hot due to the backfill, you can delay the time of the relative humidity.

MR. CAMPBELL: So it's the insulating properties of the backfill that result in the higher waste package surface temperatures and, therefore, lower humidities.

MR. FIRTH: Generally, yes. Then there are the parameter variations. So there are times where things just worked out right, so then you would have earlier failures even though you had backfill. But more often than not, the presence of backfill caused longer waste package lifetimes.

MR. McCARTIN: I guess, Jim, the long and short of it is that it's hotter longer, basically, and so it lasts longer.

DR. FAIRHURST: You get rid of any rock fall problem.

MR. FIRTH: Yes. Yes, if you have backfill. Then looking at what does this tell us for issue resolution, the viability assessment and the license application.

One thing that was noticed for the near-field

calculations is that the oxygen partial pressure and the chloride multiplication factors were both important and the chloride multiplication factor was, in part, due to some of the uncertainty and variability in the near field. We took some process level modeling and added the multiplication factor to the chloride concentration.

And since the chloride concentration was very important for waste package failure and the localized corrosion, that multiplication factor was important.

Also, the oxygen partial pressure, if you have boiling, using a one-D model, you may have depressed oxygen partial pressure for a period of time, which could then slow down corrosion.

Things that we're looking at that we need is the spatial and temporal distribution of the water dripping. But, again, we would need to connect that to waste package corrosion to effectively use that, and looking at the effect of episodic wetting and drying.

For igneous activity, there are several parameters that we identified as needing further characterization, including the re-suspension and the interaction of the waste form and waste package to magma.

As has been mentioned several times before, we need that better link between the thermal reflux and the waste package performance. And we need this basically

before we can really get a good handle in terms of how important is it and how important is it can help us in terms of our issue resolution.

Under unsaturated and saturated flow, the well pumping rates was important and we need to continue to look at this. The mixing zone thickness and several other things related to the climate and the fracture or matrix flow.

Another thing that we found was very important is that there is an absence of data for the alluvium in terms of retardation and flow properties. So that's something that for a 20-kilometer group is very important.

Now I want to go through the structural deformation seismicity and this gives a good example in terms of things that we're seeing in the process level sensitivity studies that we are then going to look at in the system level sensitivity studies and looking at for issue resolution, because this is showing something that we are making some conclusions about, even based on our preliminary studies from last fall.

The rock fall, there's a couple things that we want to verify in terms of the rock stability analyses using the UDEC code. This has to do with the yield zone and the likelihood of rock falling on the waste package and how high is the yield zone, because currently we're using the yield zone to give us the length of the rock and as a function of

the volume of the rock, which would cause a waste package to fail or not fail.

Then for fault displacement, we made what we believe are conservative assumptions and we believe we have a robust analysis and as has been mentioned before, we do not have a direct connection between the fault displacement and the mechanical failure of the waste package. We have assumed that once you exceed a certain threshold displacement, all of the waste packages in the fault zone will rupture.

Basically, what we're concluding, at least at this preliminary stage, is the direct waste package rupture due to fault displacement is not significant relative to corrosion and if corrosion is not absent, which is a good analog for C-22 at this time, then it still doesn't look like it's going to be a significant failure mechanism.

And the fault zone wet, we believe we have made some very conservative assumptions, was the most influential parameter. And it's important as we go through these conclusions to look at what they do mean and what they do not mean. And so I want to give a little bit of background in terms of the some of the assumptions that we have made and some of the caveats.

Basically, we were looking at assuming that all known and appreciated faults would be stood back from. So

the only thing causing waste package failure would be from new faults or faults that were known to be present, but were not stepped back from.

Then we considered conditional recurrence rates between 10,000 and 200,000 years. We've assumed that there was a maximum of one faulting event within the first 10,000 years. And in some of the analyses that we did, we actually forced the fault rupture to occur within the first 500 years.

We used regional recurrence rates derived from paleoseismic results and it was considered constant throughout the simulation period. So if new information comes available, then we can go back and look at how the recurrence rate figures into the analysis and we can see whether we've bounded it already or whether we need to go back and revisit it.

This regional recurrence rate had to be scaled to what is the fraction of faults that actually intersected the repository and that would slip. So we had to do an auxiliary analysis to scale, what's the likelihood of fault movement in the region to what is the likelihood of fault movement within the repository itself.

We assumed that 50 percent of the faulting that would occur in the simulation period would occur on these new or under-appreciated faults.

We set a threshold displacement that was basically equal to the minimum displacement that we would have for fault moving. Therefore, if the fault slipped, it would exceed the threshold and all of the waste packages within that fault zone would fail.

Then we made some assumptions in terms of geometric characteristics of the faults and an important thing to know is that we did not combine the effect of the fault moving, the fault slipping, and focused flow possibly occurring on that fault, and that could increase the relative significance of faulting on dose.

Then there's a couple caveats. We did not consider spatial or temporal activity, multiple ruptures, such as co-genetic and co-seismic. We, again, did not look at the increase in vulnerability due to corrosion. In part, there is no link between corrosion and the faulting.

We also did not look at or did not consider rates larger than those derived from the paleoseismic studies.

So what we're doing now is we're looking at these in terms of dose in the system level sensitivity studies and we're also going back to look at all of the assumptions and the things that we included and did not include as part of our issue resolution.

So we're taking another close look at it before we can close out the issue, but some of the preliminary results

show that faulting as a mechanism for waste package rupture does not appear to be significant, but we just want to be very careful before we go forward and close out or decrease our emphasis on faulting as a mechanism.

Thank you.

MR. McCONNELL: If I could just add. I think the uniqueness of the situation is that the initial findings were done by the structural geologists themselves, that this factor may not be important, and PA will come in and do its system level sensitivity studies and confirm that and then we'll be in a position to go out with issue resolution.

CHAIRMAN GARRICK: Some questions? George?

DR. HORNBERGER: Jim, the last few slides that you went through on the seismic were very nice, very detailed. It seems to me that there is at least enough apparent asymmetry, if you will -- that is, some of the things can be looked at in great detail, some of the other things are looked at in less detail.

And it's a person looking for his lost keys underneath the lamp post question. Are we looking at the things in most detail because they are the things that we understand and the other things we don't look at in as much detail because we don't understand them? Is there a potential problem?

MR. FIRTH: Okay. Part of the detail that I gave

in the slides for the faulting is because we are making some stronger statements based on what we did find from the process level sensitivity studies.

But as you saw, we noticed that for the dripping on the waste package, we don't have the connection, so we couldn't look at it in more detail. But what it told us was we have a problem that we need to look at. Before we can really look at it in detail, we need a fundamental connection between the dripping and the reflux to the waste package corrosion, unless we determine outside of that that even if you have dripping on the waste package, that it's not going to matter for the material that we need to analyze.

But there is always going to be the risk that you start looking at what you can and what level of detail do you look at it needs to be to a point where you can definitively say or have a good idea to say we have looked at this in enough detail that we're sure that if we want more detail, that we would not change our analysis or our perspective.

But if you deal with things such as faulting, if it was found to be significant and we have a very loose connection because we used a threshold displacement, and we saw that it was significance, then we have to ask ourselves, well, is that significance because we've made some very

conservative assumptions or because we didn't have the ability to do a link to corrosion or mechanical failure.

And it's only in terms of asking those questions that you can really get a feel for have we done enough. But you can never always know what you've not looked at, but you have to keep looking to see what is it that we have not considered.

DR. HORNBERGER: Sort of a related question. On some of the things where you have taken the approach where there is a good bit that we don't know, so you used these factors, the flow concentration factor into the drift or something like that, and in the cases where you do the analysis and it turns out that this is a no-never-mind, this seems to be a really good approach because that means that you can then not pay attention to it.

If, in fact, you find that this is important, however, in your sensitivity analysis, to a certain extent, that sensitivity will depend upon the assumptions that you built into choosing the probability distribution of those factors which are, as you say, you just characterized, we don't really have a good link back.

My question, I guess, is what do you do then? How do you know interpret the results that DOE presents for, It's say, dripping into a drift based on a two-dimensional or three-dimensional dual continuum model?

MR. FIRTH: Okay. If we find that it's not significant, then we can decrease our emphasis on it. If it is found to be potentially significant, that means that we're going to be doing more studies in terms of is it 1D or 2D analysis sufficient. Do we change our answers if we go to 3D? When is it enough? When is sufficient detail enough?

We may then -- this is the process level sensitivity studies. It may then move to the system level sensitivity studies and say well, when we look at it with everything varying it's not as important, because we made some fundamental assumptions in the process level sensitivity studies, such as the mean data set, that could change our answers, but that's why we want to look at things varying in the system level sensitivity studies.

But if we do have something that we don't have a good basis for, and as the regulator we're not the ones going out collecting the data or having the resources to fully characterize that, it means that we need to do a better job in terms of preparing ourselves for looking very closely at what DOE comes in with, and we have to look at what their analyses are, what the supporting data is, try and pull those apart to see do they hold up, and it's -- the things that we don't have a good idea for if DOE does not have a good idea for, then we have something that needs to

be worked on before a license application, and we want to be able as a regulator to be looking very closely at those things that we identify as being important or potentially important that we don't feel we have a good basis for narrowing the range or giving a different distribution.

DR. FAIRHURST: Now I'd just like to second what George has said, because you sometimes can get trapped into being held to very, very conservative assumptions which were never intended to really represent the situation, but as you've done here with the structural definition seismicity, just use them to show that even under those conditions this is not a problem, so you take it out. But if you get somewhere where you start it off with conservative assumptions, and this happened in WIPP, and not be allowed to move away from them, then you can be in severe difficultly.

MR. FIRTH: And if I can add to that in terms of what we're doing to allow us to document where we are in terms of conservatism is all of our parameter values we're working on documenting what are the ranges that we're using for a given analysis, what is the basis for that, and in some cases we indicate that we need further characterization, more information, or we're assuming it to be conservative, because we don't have any better idea in terms of what we can use.

So as long as we're doing a good job in terms of documenting what is it we're using, what the basis is for it, and if it's something that's assumed, and it's assumed because we don't have a lot of information, as we get more information or better justification then we can -- we have reasons for backing away from it.

Part of the problem is if you use things and you don't clearly document how you got those, because then people will not see where that came from or where it applies and where it does not apply.

Tim wants to add something.

MR. McCARTIN: Jim, if I could just -- I mean, really our code and parameters is our way of trying to prioritize how we would review the DOE effort, and it's a way of -- yes, there's areas where maybe we can cast aside other areas. We need to prioritize what we're going to look at, and using our code is a way -- we know how it works. We know what the assumptions are. And so then it identifies for us where we need to look closer at the DOE effort.

CHAIRMAN GARRICK: Any other questions?

[No response.]

Thank you, Jim.

MR. FIRTH: Thank you.

CHAIRMAN GARRICK: Yes, Richard, you're going to take us up to lunch?

MR. CODELL: Good morning. I'm Richard Codell, and I'd like to acknowledge Rose Byrne, who contributed to this effort on the sensitivity analysis.

The purpose of my presentation this morning is to show the sensitivity of performance measures to the input parameters primarily, and also to alternative conceptual models including in some cases scenarios. This encompasses alternative designs and alternative understandings of the design. And, third, to determine some measure of the relative importance of the various technical areas to the performance at a repository.

Now first I'm going to start out with the classical sensitivity analysis on a run. Our base case run, as I define it here, is the 625 alloy over -- for the inner overpack, carbon steel outer, no cladding, bathtub model for release, no matrix diffusion, no backfill, the 20-kilometer receptor group, up to 50,000-year maximum time, no vulcanism or faulting, but since this was an evolving analysis, some of the runs were done without seismicity. Those are the alternative conceptual model part. But the sensitivity analysis did include seismicity and also the later version of the code which has some minor differences in models and parameters.

The sensitivity analysis relied on a number of statistical tests, and we use these to analyze for the most

important radionuclides and the most important variables. Some of the statistical tests include a rank and other transformations of input and output, correlations between inputs and output both for the raw and the transformed data, stepwise regression and fitted linear models of the raw and transformed variables. So that's what you'll see next. I'm just going to show a small representative sampling of some of this sensitivity analyses which I think are most graphic.

Now this first of the sensitivity slides shows a stepwise linear regression for 10,000 years, and this was on the 400 vector set using TPA 3.1.4, the latest version, with seismicity, and this shows that for 10,000-year dose, peak dose within 10,000 years, there are approximately seven variables.

You can see very clearly in this plot which shows as you add -- as you look at the most significant variable, and then the next most significant down the line, and there are 157 variables in our analysis, that there are only about seven that show up pretty significant, and then up to about this point it starts to trail off into less and less significance. So the seven factors for 10,000 years, several of them have to do with how much water reaches the fuel. That's this one, this one, and this one, and this is the amount of fuel that's wetted, the fraction of the fuel that's wetted. And then these two have to do with the waste

package corrosion.

There's -- you might ask why isn't it more sensitive to waste package corrosion. Well, these are mostly very low doses for 10,000 years, and most of those doses, my interpretation of it, is that they're coming from this very small fraction of initial failures that have nothing to do with corrosion. So that's why they're fairly down in the noise.

DR. HORNBERGER: Dick, residual sum of squares aren't that informative. How about fraction of variance explained?

MR. CODELL: Well, I didn't do it for this case, because of the way the code is formulated it wasn't easy to --

DR. HORNBERGER: Roughly.

MR. CODELL: To do it. But for 50,000 years, which is on the next slide, the seven -- there were seven variables that were before the break point. Well, let me put that one up a bit. I'll show you

DR. HORNBERGER: Yes, I have a second related question, and that is, when I think about like the factors that you have there, the flow factor, the amount of water getting to the -- the container being important, it would really be related to the product of all those things, and my question is, did you do a log regression?

MR. CODELL: Oh, yes. Actually -- well, this was a -- this was a rank regression.

DR. HORNBERGER: Yes.

MR. CODELL: And actually the -- I had more -- more runs on 50,000 years because the 10,000-year data were extracted from the 50,000-year data, and not all the information was saved, so I couldn't go back and I'd have to do a new run. But for the 50,000-year runs, it's the same sort of curve, and this is also rank regression. But it was almost the same using log transformation of all the variables. And in fact of the seven factors that I considered important from this stepwise regression, the r squared of the logs was 79 percent. So it was pretty good. And 79 percent of the variance was explained by these seven variables for 50,000 years.

So it is actually the products of all these things, as George points out. And in this case the sensitivities are different than the 10,000-year. Here we see that the most important factors are how much fuel gets wet, how much is an action contributing to release, not how much -- not so much how much water is getting there but how much fuel is exposed. And these -- this first factor, well, that's this factor, this factor, and primarily. But the -- the most important factor, which is pretty much equal to these, is the retardation of the neptunium in the alluvium.

That turned out to be very important.

And then further down the list are factors that have to do with the corrosion of the waste package, and this one is retardation of americium in the alluvium.

There are other tests, too, and they all pretty much confirmed -- I just picked a couple that were clearest.

Now the next figure shows the relative importance of the radionuclides. This is for 50,000 years, and this is a -- this is the average contribution of the radionuclides for all 400 sets at the peak, at the peak dose. And very clearly neptunium is far and above everything else. Americium is second. Plutonium doesn't show up here, but we're looking into some -- we're looking further at some of our assumptions here and may revise that later on.

The technetium and iodine which you think might be important hardly make a blip.

CHAIRMAN GARRICK: Now where's the peak on this? On this time span?

MR. CODELL: This is peak within 50,000 years and it's not explicit on this bar chart. But somewhere -- in most cases it's at 50,000 years --

CHAIRMAN GARRICK: Yes.

MR. CODELL: But the highest ones tend to be earlier.

CHAIRMAN GARRICK: So you haven't reached the

peak, I guess.

MR. CODELL: For the smaller ones. I don't have that plot, but the few cases I looked at, when you have the highest peaks, they happen before 50,000 years.

Now the next set of results are the comparing alternative conceptual models. The -- and these are variations in waste package, waste form, and geosphere. We compare these to the base case, which is the sensitivity run we just saw. and now that was done with 400 realizations or vectors, but all these were done with only 200, but -- or apparently pretty good agreement between 200 and 400. Two hundred vectors, using a very fast state-of-the-art work station, took 16 hours. So it's a fair amount of computational effort here.

We considered only the 20-kilometer receptor group and looked at 10,000 and 50,000-year time frames.

The next two figures show the listing of the alternative conceptual models. The first one is the base case except for 200 vectors that we just saw, and then I'll point out what these are. This is -- the second one is the same but with C22 as the inner container material. Then we have 625 material but with backfill, 625 material but with matrix diffusion, and this one is using the C22 material but with a larger flow per container to account for the fact that we're not in -- we're not talking about pitting

corrosion, we're talking about general corrosion at a later time. But once it does fail, you'll have bigger holes and more water getting in. So this case accounted for that greater amount of flow.

This one is the base case but with cladding protection, and the cladding protection was factored into the model by saying that only half of one percent of the surface area of the fuel's exposed.

The next six are on this slide, and No. 7 is -- we take one-fourth the number of containers and give them four times the amount of flow per container. So we have the same amount of water getting in, but you might think of this as a focused flow model. This is an alternative conceptual model of the flow where maybe you have some sort of major structures that are focusing the flow to more flow to fewer containers. See what difference that makes.

This one is looking at totally -- all the containers fail at time zero, and this one is no retardation in the geosphere. This is to get a sense of how important these two multiple barriers are to the total performance.

And flowthrough is an alternative conceptual model of the source term where we have some researchers at DOE suggest a very small amount of water getting into the container but bathing the -- bathing the fuel with a very thin water film, and this where you might see some

solubility limits start to kick in where you wouldn't have seen them otherwise, because there is such little water.

These two I've added since the technical exchange. This is natural analog. This is where we used release rates based on the Pena Blanca natural analog data and plugged those directly into the source term model rather than using our dissolution model.

The second one is another flowthrough model, but using the carbonate leach model, which gives you orders of magnitude faster leach, and this was suggested by someone at DOE to look at the case where you don't have any water that contains silica and calcium because it's coming from condensation only inside the waste package, and this would lead to a higher release rate, but where you might see once again solubility limits kicking in.

The first -- as a prelude to the results I wanted to show some results of the corrosion model for C22 versus 625, and these are histograms of the failure times as reported by the code. They're only -- this is only an approximation of the failure rate histogram of all the waste packages, but makes the point. The first one is for no backfill, which is our base case. This is the histogram of failure times for the C22, and this is for the 625. They're dramatically different. We have a lot of early failures here. These are from pitting. This is only corrosion now,

not anything else.

And then these are general corrosion failures trailing out. We don't have any of these in the C22 case. It's only general corrosion.

The next one is the same but shows with the effect of backfill, and, well, many of the same features are there. The pitting corrosion is muted for the C22, and both curves are pushed back further in time, because they stay hotter longer.

These are the results for the alternative conceptual models showing the mean peak dose for 50,000 and 10,000 years and also the percent of the realizations with dose less than the mean to point out how skewed these are. These are -- the mean is being affected by the extreme high dose calculations, and the skewness is obvious. And also these are -- the results are presented several ways. There's some CCDFs and also scatter plots done and a few cases where it makes a point.

Now the first of these two bar charts shows the 50,000-year result. This is our base case, and these two show the great importance of retardation to the mean, and also the waste package integrity. Also, the C22 base case is here, and it makes about a 50-percent difference from the base.

The backfill doesn't make a great deal of

difference. Matrix diffusion, which is in our transport model, not too much. And the -- these are the percentages less than the mean, and you can see that this -- they are very skewed results.

DR. WYMER: What was your backfill material?

MR. CODELL: The backfill material was crushed tuft, I believe, and the properties of crushed tuft were put in there. It only affects the thermal model, insulating.

DR. WYMER: Some other things could have a dramatic effect, of course, different kinds of backfills.

MR. CODELL: Right. Yes. I think -- I'm not sure if that was sampled or not. I guess it was. Some of the thermal properties were sampled for the backfill.

MR. McCARTIN: They can be. I don't -- I'd have to look to be absolutely certain whether we did.

MR. CODELL: Yes. I don't remember what they are offhand. There was a range --

MR. McCARTIN: They're samples.

MR. CODELL: Of properties. So we have more detail on what the sensitivities -- it is not one of those things that turns out to be very sensitive, because I don't recall it in any of the analyses.

DR. WYMER: But it could be.

MR. CODELL: Yes. It didn't seem to show up, but then we're only looking at its thermal properties, not any

other contribution backfill might have.

DR. FAIRHURST: So the flow model is really a one-dimensional so that what comes in, the only thing to exit downstream is retardation, are the flow time.

MR. CODELL: All our models for transport are -- their extracted models are one-dimensional.

DR. FAIRHURST: What you're doing here is one-dimensional.

MR. CODELL: Yes. Well, it's multiple one-dimensional. It's -- because -- so there is some multi-dimensionality to it. It's because it's just a bunch of parallel paths. So it is more than one-dimensional in that regard.

MR. CAMPBELL: Dick, when you have flow through the backfill, that is by diffusion? Is that how the model --

MR. CODELL: The backfill -- the backfill does not affect the flow at all in the model. The -- well, the only way it would affect it is by keeping the failure time -- increasing the failure time because the -- we don't start the calculation till the waste package fails. But there's no effect of backfill on flow. There is a part of the release model that looks at the contribution of diffusion through the backfill. This is generally minor.

Any other questions?

Okay. The next figure shows the results in the same order as the first, but those were ranked -- the first one was ranked from highest to lowest. This maintains the same order, but for 10,000 years, to point out that the order doesn't remain the same, that some things become more important, although the first -- the highest ones, retardation and totally defective, are still -- turn out to be the most important thing.

Let me move on here. The result -- now to look at the results in a little more detail, I have a lot of figures in the back -- in the backup slide section. I just pulled out a few. This one shows the effect -- these are now plotted as CCDSs of peak dose for the 200 vectors at 50,000 and 10,000 years. This one compares the base case to the C22 case. The vertical lines are the means of the two distributions.

The -- now this -- this curve shows rather evidently that the C22 makes much more of a difference at 10,000 years than at 50,000. Because of the very long lifetime of the waste packages, there is a big spread between these two distributions. Not so much at 50,000 where in both cases -- in both materials they've already failed for the most part at 50,000 years.

Now the next figure is exactly the same data but plotted in Cartesian rather than log-log coordinates. I

just wanted to point out that how skewed these distributions are. When you look at it in this light the -- most of the doses are rather small. There's only a few that contribute to the mean.

Now the next figure shows you might have missed a result. If you look at the result of -- this is the base case now versus the focus flow. This is where we take one-fourth the number of waste packages that would have gotten wet and give them four times the flow. You don't see anything dramatically stand out in these figures, but if you plot it a different way, that is, you plot the dose of one -- if you plot the dose of the base case versus the other, the peak dose of the base case versus the peak dose of the focus flow case, you see that the slope of this line, which is -- this is not a fitted line, this is -- this line that has a slope of one-fourth, one-fourth being one-fourth the number of waste packages.

So here this says that it's the amount of fuel that gets exposed, not the flow that affects the release. And so water flow isn't so important, it's -- at least in our current understanding of the model. It's how much fuel gets exposed. I think that's an important conclusion.

Finally I'd like to summarize these results. Neptunium and americium most important nuclides. And that there's different sensitivities at 10,000 and 50,000 years;

10,000 years we have -- the most sensitive factors have to deal with water flow and waste package lifetime, whereas for 50,000 it's -- has more to do with the retardation in the alluvium and the fraction of fuel exposed, and then waste package lifetime is down the list.

As far as I could tell I didn't see any great effective of seismicity in the performance, even though we included it in the latest model.

The statistical tests largely agreed on the importance of the variables, and we did a large number of these, and Rose Byrne helped with a lot of that.

Now the observations from the alternative conceptual models are that there's a great importance -- the retardation in the geosphere and waste package lifetime are important, and the factors that contribute to long waste package lifetime like C22 versus 622 are significant, and when we looked at the case where everything failed, right off the bat that made a very big difference. Things like backfill and matrix diffusion don't make a lot of difference in our results.

The fraction of fuel exposed is much more important than the amount of water contacting, and we could see that from the model which included cladding and focused flow.

Solubility is relatively unimportant in our runs

except for those two cases where we looked at the flowthrough model and assumed a very small amount of water getting in, and then at that point you did start seeing effects of solubility of neptunium. Our values are about an order of magnitude higher than DOE was using. That's in a constant state of flux. I don't know where it stands today. But if we -- there are only a few cases where solubility seems to make a difference.

And finally the natural analog data suggests that the doses will be considerably smaller than our base case.

Thank you.

DR. FAIRHURST: You mentioned the natural analog. Where is that?

MR. CODELL: That's in Mexico. Brett Leslie may -- was actually one of the participants in that, and he could fill you in on a lot of detail. He recently published a paper on it.

MR. LESLIE: Yes, this is Brett Leslie from NRC staff. The Pena Blanca natural analog is a uranium ore body in Chihuahua, Mexico, Pena Blanca uranium region, ore deposits. It's remarkably similar, being an unsaturated silicic volcanic tufts. It's in the unsaturated zone. And it's basically based upon what we know on the amount of infiltration and percolation and also the solubility of uranophane. And so we've used that information to come up

with a release model based upon what we expect from temporal constraints would be the release from the Pena Blanca site. And then scaling it up to Yucca Mountain.

DR. FAIRHURST: You say you've recently published something on that. Right?

MR. CODELL: Brett is one of the authors from the center, and it's in Water -- what was it, Water Research?

MR. LESLIE: Yes. We'll get you some information on that.

DR. FAIRHURST: Yes, I would like to. I'd be interested in that.

MR. CODELL: There's also a number of center reports on the same subject.

DR. FAIRHURST: Just one publication.

CHAIRMAN GARRICK: It's obvious that you've been very busy the last few months.

In your technical exchange meetings, have you had an opportunity to get a sense of how your sensitivity analysis stacks up against the sensitivity analysis work that DOE has performed? You've alluded to it a couple times.

MR. CODELL: I think we see some differences. I think the most obvious one to me is the solubility issue for neptunium. Now their solubilities are lower, and that makes a big difference in the results. If you're only worried

about solubility, then a lot of other things become unimportant. It doesn't matter how much surface area of the fuel's exposed. If it's solubility limited, it's solubility limited. And this is a big difference in our results. That's the main thing that pops out at me.

CHAIRMAN GARRICK: Solubility is a rather basic piece of information.

MR. CODELL: It's basic but very hard to get at. There's a -- maybe John did you want to comment? John Bradbury -- leave these issues to chemists.

MR. BRADBURY: This is John Bradbury. The NRC used information from experimental determinations by Heino Nietzsche and somebody named Efford. They were experiments done both approaching the equilibrium solubility concentration from oversaturation and undersaturation. The question arises as to what phase, what neptunium-bearing solid phase precipitates out of those experiments from oversaturation.

There have been some -- DOE has postulated that the phase that came out of the oversaturation experiment was metastable and thus is not expected in a situation where the waste form is dissolving and secondary phases are reprecipitating. If that is correct, then the lower solubilities that they pick are appropriate. At this point though we can't -- we're not certain that that postulate is

correct, so we're going with the more conservative number.

CHAIRMAN GARRICK: Thank you.

Any other comments, questions?

[No response.]

We want to thank the staff for what I think was an excellent series of presentations. This I believe was more than we expected, and very well presented, and we appreciate it a great deal. And I'm sure it will lead to some questions later on. So please stand by.

MR. McCARTIN: One question I guess I have. There was a roundtable on the PA. Is that sort of -- are you intending to do something after lunch on that or I guess --

CHAIRMAN GARRICK: I don't think so.

MR. McCARTIN: Okay.

CHAIRMAN GARRICK: Not unless the members have some burning questions that they would like to pursue at this time. And I haven't gotten a reaction of that. George? Ray?

No. I think not. I think we're satisfied.

Yes. Yes. Abe Van Luik of DOE would like to make an announcement.

MR. VAN LUIK: Yes. I promised to keep it to a couple of seconds. This is Abe Van Luik, DOE.

Just in the interests of no surprises, tomorrow when we show the results of our latest calculations to the

TRB, they will be different from what is shown in the technical exchange a few weeks ago. The main cause of the difference is that we are now taking credit for cladding, and we have basically abandoned a three-dimensional groundwater flow model, the saturated zone model, to go to a much simpler 1D representation, very similar to what the NRC is doing. The other changes that were made were minor in comparison to those, but we made these changes for a number of reasons, but some of the comments that were made about the difference between our sensitivity analysis and the NRC's have kind of faded away, I think, because of that.

The neptunium solubility importance goes way down when you take credit for cladding. Cladding fails in our model about a thousand times slower than the C22 fails, and this is kind of consistent with what we're seeing in the batch test degradation testing at Livermore. And given that, the exposure of spent fuel now becomes the more important parameter, you know, in controlling the near field releases.

I thought you'd want to know that.

CHAIRMAN GARRICK: Yes. Thank you.

Any other questions from the Committee, the staff, anybody else?

All right. I think we will adjourn for one hour for lunch. Thank you.

[Whereupon, at 12:00 noon, the meeting was recessed, to reconvene at 1:00 p.m., this same day.]

AFTERNOON SESSION

[1:00 p.m.]

CHAIRMAN GARRICK: The meeting will come to order.

This afternoon we are going to talk about Viability Assessment Guidance. The lead member of the Committee on this subject is George Hornberger, so I will turn the microphone over to George.

DR. HORNBERGER: And I see Mike Bell is already getting wired up. We are going to hear from Mike on the topic of VA Guidance.

MR. BELL: Thank you, Dr. Garrick and Dr. Hornberger.

As I know, the Committee is well aware that the end of this fiscal year, the -- well, actually, for the benefit of the transcript, my name is Michael Bell, I am the Acting Chief of the Performance Assessment and Integration Branch in the Division of High Level Waste Management, and I am here to talk to the Committee today about the guidance that is being developed for the staff's review of DOE's Viability Assessment.

And as I know, the Committee is aware the department is required by statute at the end of this fiscal year to prepare an assessment of the viability of the Yucca Mountain site for further development as the national repository for geologic disposal of high level waste.

You were I guess briefed to some degree by Margaret Federline, our Deputy Division Director in an earlier meeting, and I believe we shared with you the preprint of the paper on this topic that is going to be presented next month at the International High Level Waste Conference in Las Vegas, and I will just today be touching on some of the highlights of that paper and perhaps maybe even be able to give you some other insights into the management thinking in how we are approaching the VA.

To refresh everybody's memory, the Viability Assessment has been characterized by the department as a management tool. Basically, it is an investment risk decision-making document, so that the Congress, given the costs and some information about the likelihood of success of being able to develop a repository at Yucca Mountain, can decide whether the country should continue to fund the project.

NRC, in the appropriation bill that directed the department to develop the VA, was not given an explicit role. Our expectation is that when Congress gets this document from the department, however, since there are very significant regulatory matters addressed in it, that the Congress will be asking the Commission for its views and we are getting prepared to review it so that the Commission will be able to respond to any Congressional questions that

we may be asked.

Not on the slide, but since this document will be a synthesis of where DOE presently stands in its design of the repository, its total system performance assessments, and will lay out its plan for how it is going to get from where they are today to the license application, just for the ongoing work that we are doing in the program, it just makes sense to review it and to factor it into our interactions with DOE over the next several years. Presuming, of course, that Congress's risk investment decision is to continue the program.

Now, our objectives in reviewing the document are quite a bit different from DOE's in preparing it. As the potential regulator of the facility, we are going to use it to essentially see where we think DOE stands in their program to eventually prepare a license application, currently scheduled for March 2002, just about four years from now.

We want to be able to identify any potential licensing vulnerabilities that we may see now. Identify any shortcomings we may see in their test plans, the other activities that they are doing that will lead up to the license application, and point them out to the department.

Basically, I think in previous meetings you have probably heard us use the expression "no surprises", and,

basically, if there is anything that we see in the DOE program that is deficient, we want them to be aware of it so that, you know, for the success of the national program, which we are all participants in, they can take the appropriate steps and deal with that in the next four years.

Now, the Committee is quite aware from the series of briefings over the last couple of years that basically our program was refocused about two-and-a-half years ago. We are essentially focusing on the ten key technical issues that we identify that are important to post-closure performance.

There are a number of aspects of the DOE program that will be addressed in the Viability Assessment that our present program does not encompass. Things like handling in the surface facilities, many of the pre-closure activities, and even some aspects of post-closure that don't fall within the scope of the key technical issues at the present time.

But we would focus on the knowledge we have gained and the work we have done in the key technical issues that is being summarized in the Issue Resolution Status Reports, the acceptance criteria contained in the IRSRs. We will be using the results of our own sensitivity analyses with the TPA code that you have heard described this morning.

And didn't the staff do an outstanding job, both the Performance Assessment staff in presenting it, and the

KTI leads in answering the questions that came up? I have rarely seen a more professional presentation before one of our Advisory Committees.

DR. HORNBERGER: We agree.

MR. BELL: And, as you can tell, leading up to my third bullet, to the extent we can, our review of the VA is already underway. We are reviewing all the DOE work, their total system performance assessment that is going to be synthesized in the VA. We have reached an agreement with them. There was a technical exchange. In fact, we used this very room about two months ago to go through all the supporting documents that they were developing for the EA and essentially had a discussion on which ones we were interested in that we felt were most important to the kinds of things we were going to be reviewing.

They are the kinds of things where we have been participating in the expert elicitation meetings that DOE has been conducting. We have been observing those in a number of areas. We have been observing their workshops where they are doing their own model abstraction work. And, basically, we have been allowed, we think, to get a very good window into the process that DOE is using to develop the models, do the technical work, and that will eventually be documented in the Viability Assessment.

And we, in the IRSRs, have been real-time

considering that information, writing down our assessment of it, and using it to resolve open issues with the idea that they will have feedback in all the areas we have defined as important to post-closure isolation before they come out with the VA.

Basically, the last bullet just says when the VA itself actually comes out, if both parties follow the "no surprises" approach, our review of the VA will really be just confirming what we have already been observing and reviewing this last year, year-and-a-half, and writing it up.

Now, because of things that happen in a large program like this -- you just heard this morning, Abe said, well, everything that we told you last month has changed. Just within the last couple of months they have changed the material of construction of the corrosion-resistant barrier. So, to the extent that -- now, there are major changes that may pop out in the VA document when it finally gets published. We can't actually sit down and write our report to Congress right now. We will have to wait till it comes out and compare what we know now to what actually gets printed.

I just think it is worthwhile going through the four major parts of the Viability Assessment, as DOE has laid it out, and talking about what we, in fact, would be

able to do. The four major parts are listed here. Basically, the preliminary design concept will primarily be focusing on the designs that affect long-term performance and post-closure.

Because they have got to do a cost estimate and tell Congress what this whole program is going to -- what this facility is going to cost to build, operate and eventually close, they have got to include a lot of detail in the design concept to develop that cost estimate, that we aren't really going to look into very much. The receiving facilities, handling facilities, all the surface facilities.

Even things that potentially are important to safety handling systems for surface facilities that will be a major decision when NRC finally authorizes construction, because we aren't dealing with them in our key technical issues now, we are simply going to say in our comments that the scope of our review is limited to certain areas, you know, we are not commenting on these other areas, but we think there is little likelihood that there is some fatal flaw in some of these areas, whether because they are the kinds of activities that have been conducted before in other kinds of facilities, and that the industry has experience in dealing with.

The total system performance assessment, we will review in as much detail as we can. I mean that we see as

the principal technical focus of our current program and it will continue to be all the way up until the time of the license application.

The license application plan we see as another key piece of this, because, basically, every area where we see a vulnerability, some parts of the model that there is a disagreement between DOE and NRC about what is the right way to approach an area, the LA Plan should have something in it for DOE over the next four-year period to try to gather better data to either confirm their model, improve their model, justify their data, and we see the LA Plan as being a very important piece of the VA as far as the NRC is concerned.

On the other hand, our review of the cost of construction and operation is going to be very limited. Basically, the cost is mainly a matter that DOE and the Congress can work out between them. But what we do want to do, is if there are any regulatory costs that need to go into this, we want to make sure they are recognized. And we also want to make sure they are not over-inflated. We don't want to have a situation where the department goes to Congress and says, well, this is very expensive, but it is all because of NRC laying on a bunch of --

CHAIRMAN GARRICK: You have heard that before.

MR. BELL: -- conservative regulatory

requirements.

DR. HORNBERGER: Mike, I assume that when -- the kind of things you will be looking for when you look at the LA Plan would be the lists from the acceptance criteria in the IRSRs. Would that be the primary basis for the plan for the review of that?

MR. BELL: Well, I guess that is the starting point. But then what the IRSRs and the acceptance criteria in the IRSRs may end up doing is defining some piece of information that is needed. Basically, then you ought to be able to go into the LA Plan and see some line item there where DOE will have that piece of information by the year 2002.

The products of our review are actually going to be in two phases. The first will be done rather quickly in anticipation that the Commission won't get very much time to respond to Congress. That within two months of the VA being published, we want to have a paper on the way to the Commission and, hopefully, in about three months, the Commission would have completed its review of the staff's comments and be comfortable with what they might say to Congress.

Because this level of review is the sort of thing that the Commission will be talking to Congress about, these are not the detailed technical issues, they are really

focused on do we see any fatal flaws, licensing viabilities that Congress ought to know about before it makes its decision on the future of the DOE program.

The other level of review will be ongoing, longer than a two to three month time frame we will be continuing to look at the data, the assumptions, the details of the models in the VA, factor them into our interactions with the department, and we actually have a Rev. 2, I think, of the IRSRs that's planned that would include anything we have learned, any new information that would be incorporated into the IRSRs, which are growing, living documents, that, hopefully, by the year 2002 will all be complete and the issues will be largely resolved.

I guess one thing of interest to the Committee might be where would they fit into all this. And, basically, the three things that are listed, today's briefing, the ongoing interactions which, from time to time, either Committee members or Committee staff have been attending. The nearfield environment and engineered barrier workshop is scheduled for June. And there has got to be an opportunity, I guess, to come down and talk to you in the fall, and perhaps we will work something out on that Friday morning.

So, basically, that is my summary of the approach we are taking to the review of the Viability Assessment, and

I would be happy to try to answer any questions.

DR. HORNBERGER: Thank you, Mike. Let me ask a question, just to start off here, Mike. I guess, was it March that Margaret gave us a very preliminary briefing that -- well, at any rate, it was several months ago. It might have been February.

MR. BELL: Yeah, March was just last month, so it must --

DR. HORNBERGER: So it must have been February.

MR. BELL: -- have been February.

DR. HORNBERGER: Okay. At that time I recall that Margaret had expressed concern about the ability to look at alternate designs. Is that still a concern? And if it isn't, why isn't it? And if it is, what are you going to do about it?

MR. BELL: Well, the issue arose because of the TRB's annual report to Congress. TRB is pressing the department very hard to not only look at the reference design but at alternatives. And a wider variety of alternatives than the kinds of things DOE showed the Committee here, which were mainly alternative engineered barriers.

The TRB was talking about different layouts, different heat loadings, different -- you know, do you really want to continue this large, I guess, 15 -- or is 12

or 22 fuel element waste packages or do you need to go back and revisit some of those designs?

They were concerned about things like maintainability of the drifts and some of the kinds of issues that Dr. Fairhurst was alluding to this morning. Are there things you could do if you rethought your thermal loading and the size of the drifts and such that would improve the stability of the rock openings?

And our concern was that such fundamental rethinking this late would really end up in a very superficial VA that would not -- well, we would not be in a position to review and probably would not help the national program very much.

When the Commission -- the TRB actually came in and met with the Commission within the last month and they appeared to have modified their position somewhat, more along the line of the staff's, which is to ensure that you do have a robust reference design, but to the extent you can, look at alternatives. And after VA, you ought to do more work on alternatives. And I think they modified their position. So, to that extent, I think that problem may be behind us.

DR. HORNBERGER: And so you are confident that you can effectively evaluate the kind of differences in design that are less severe, such as including drip shields or

things that we have heard about from DOE?

MR. BELL: Well, see -- let's see, there are only a limited number of alternatives that DOE had proposed to address in the Viability Assessment. I don't remember if the drip shield was one, was it? I just don't remember.

But one interesting one was that they were going to look at the case with backfill.

DR. HORNBERGER: Right.

MR. BELL: And we have been gearing up to be able to review that.

DR. FAIRHURST: Thermal loading, might have to expand it.

DR. HORNBERGER: Questions? John.

CHAIRMAN GARRICK: Yeah a couple. We keep hearing that the NRC has no official role or official requirements with respect to the Viability Assessment, and that is usually followed with --

DR. HORNBERGER: But we are going to review it anyway.

CHAIRMAN GARRICK: -- what we are doing today, that Congress is expecting to -- we expect Congress to ask the Commission. Has there been any signals or any indication that that won't happen, or will happen?

MR. BELL: No, as a matter of fact, I think -- you know, we get Congressional questions on our budget and such

like that. We get questions to answer about it from Congress as to what are our plans to review the VA. So we're anticipating there are at least some committees in Congress that are expecting to see NRC's views on it.

CHAIRMAN GARRICK: Supposing Congress is silent? Is there any -- is there a plan B with respect to what NRC might do or --

MR. BELL: Well, it's still useful information to proceed to interact with the Department on. So, I mean, it's not lost effort if in fact Congress doesn't ask. It's --

CHAIRMAN GARRICK: Yeah. Now, is the Department -- given that there's no official regulatory requirement with respect to the viability, has the Department of Energy indicated anything relative to resources that they may make available that are required for the NRC's review? In other words, is there any problem there, or do you have an unofficial plan?

MR. BELL: No, I mean, it's the resources to review it are included in our FY-99 --

CHAIRMAN GARRICK: Yeah, but what about the DOE's resources, they're --

MR. BELL: Oh, meaning, are they budgeting to interact with us?

CHAIRMAN GARRICK: Right.

MR. BELL: You know, in some fashion I'm sure they are. I think it really can be viewed as just part of the ongoing prelicensing consultation between the two agencies. And it just happens that it, you know, at this point in time is taking a form of this document that the Congress has asked for called the viability assessment.

CHAIRMAN GARRICK: Has there been any discussion within the staff regarding the value of the viability assessment exercise with respect to the revision of 10 CFR 60? I don't know what the schedule is for the revision of Part 60, but one thought can't help come into people's minds that given that this is moving in the direction of a facility-specific regulation or at least some part of it, given this milestone which is rather significant, one might say that the timing of the revision of Part 60 should allow for lessons learned from the --

MR. BELL: And I think it does. I mean, the present schedule is still the one you saw in SECY-97-300 which is to get the proposed rule to the Commission at the end of this fiscal year which would suggest the proposed rule in the Federal Register in the fall, is it 75-day comment? 75-day comment period and so that would be transpiring, you know, over late calendar year '98, early calendar year '99. When we have had the chance to review the viability assessment the Department, if it had any

insights from the viability assessment that it thought should be brought to bear on the new Part 63 would, I'm sure, be submitting comments on the proposed rule that would reflect what they've learned in the viability assessment.

I don't think we're too out of sync there.

CHAIRMAN GARRICK: Charles.

DR. FAIRHURST: Do you know if you will be asked to look at the potential of leaving the repository open for 100 to 200 years?

MR. BELL: Let's see, we, I guess, learned that Lake Barrett is discussed with the TRB that --

DR. FAIRHURST: It was mentioned here when DOE gave a presentation last time.

MR. BELL: Well, they are now considering a design so that if the future societies chose to -- you know, Part 50 only -- or Part 60, and I presume we'll probably do the same thing in Part 63 only requires a 50-year retrievability.

The Department had already decided on their own for 100 years of retrievability and in either case you're potentially leaving to, you know, our grandchildren and great-great-grandchildren the burden of deciding, you know, to close the repository or not. But you could envision a situation where you would foreclose the option if you didn't design it properly so that the openings could be maintained.

And I think all the Department is saying is, they're going to modify the design of the openings so that if 50 or 100 years from now the decisionmakers at that time decide that it would be a good idea to, you know, watch this facility for another generation or two before making a decision to close it, they're not going to foreclose that option.

DR. FAIRHURST: As I recall Margaret Federline who is here said that you intend only to look at post-closure performance; right?

MR. BELL: Well, I think the presumption would be eventually, you know, some generation would decide to seal the facility. And, you know, whether that happens 50 years after inplacement or 150 years after inplacement, we would want to make sure that for the long-term the facility was save.

DR. FAIRHURST: But there are a lot of things you could do in that 100 years that could significantly change the long-term performance, you know, ventilating the repository, for example, and keeping it and cooling and change the thermal --

MR. BELL: Well, you're absolutely right. I guess we'll have to see what kinds of reference design and then alternative designs the Department may come up with.

DR. FAIRHURST: I was only thinking, you know, that if Congress feels that that option exists they may very

well -- some of them may want to go over that. There's a strong political push to do that. That's pure conjecture, and you're right.

CHAIRMAN GARRICK: That's an interesting -- it's a little bit off the path, but it's an interesting commentary because we're talking about a facility that will be operating longer than any facility that's currently licensed, probably, and that's not even the licensing. That's not even the period for which it's licensed.

There are two reasons why this is very interesting. One is, it is a facility, it is a nuclear facility and it will be operating for a long time before it's closed, whether it's 50, 100, or 200.

The other thing that's very interesting about the operations phase is just as you say, Charles, there's an opportunity for the way in which the facility is operated to impact the long-term performance. And one of the most obvious areas that you could impact is the thermal loading. But you could also imagine that you could have a major impact on the containment of the waste package and a variety of other things. Because the more you have it around and the more you can make measurements, the more information you gather, the more input that you can provide in the long-term performance analysis and reduce uncertainty.

So, one of the things, I think this committee has

had some interest in is maybe learning a little more about eventually the NRC's position relative to the operating phase. And even some people might even be saying, that might be the only phase.

Anyway, as we say, that's a little bit off path, but I think it's something of considerable interest.

MR. BELL: Well, and I think some of these are exactly the kinds of considerations that TRB is trying to get the Department to, you know, reconsider. For a long time the approach at Yucca Mountain was the hot repository and placed the wasted and take advantage of the drying out which, you know, has some advantages on in some respects, but an alternative of, you know, waiting and cooling long enough so that things are very cool and corrosion rates aren't very fast compared to 90 percent relative humidity at 90 degrees centigrade may also have advantages and they would like DOE to go back and do those kinds of tradeoffs which were done -- done once, but the program and some of the thinking has changed since.

DR. HORNBERGER: Mike, one of the other things that has come up before, too, you talked about how you -- the LA plan that DOE will put forth is also an important aspect of the review for you. Concern has been expressed that the LA plan is important in terms of providing a road map for how to get from here to a final licensing. And the

concerns that have been expressed is whether or not that -- the overall plan will be robust enough to do that.

And I guess the question I have for you is, it's easy to think in terms of the details of looking through the LA plan as to whether or not this particular data set of plan has been put in place to collect these particular data. But how about just the overall -- the overview -- the overarching view of can we get from here to where we want to be? Do you know what I mean? It's sort of a higher-level review almost of the LA plan. I assume that you'll be looking at it that way as well?

MR. BELL: Well, yeah, I'm sure we will, but I think we've probably already jumped to the conclusion that the devil is in the details.

DR. HORNBERGER: Okay. Okay.

CHAIRMAN GARRICK: Ray?

DR. WYMER: No.

CHAIRMAN GARRICK: Okay. Thanks a lot, Mike.

MR. BELL: Thank you.

DR. FAIRHURST: Could I just throw something out. I might be getting off the track a bit, Mike.

CHAIRMAN GARRICK: Maybe you had better stand by, Mike.

DR. FAIRHURST: No, I was just wondering if there's any interest, although not required, to have any

other independent international look at the plan? Yeah, in the VA just to make sure that you've got -- people have got similar problems and do you get --

MR. BELL: I mean, you're thinking of some sort of international peer review like was done at WHIP or something like that?

DR. FAIRHURST: Sure. Yeah.

MR. BELL: I think maybe you ought to ask Lake Barrett that tomorrow morning.

DR. FAIRHURST: Well, it could equally be NRC saying they want to be assured of international credibility and not just overlook something that you and DOE have been together and working this out, and somebody who hasn't may see some things that, you know, you would say, why didn't we think of that. It's just purely --

MR. BELL: Well, I think this Agency has traditionally viewed the fact that we have eventually got to go to a licensing board to do an adjudicatory proceeding as being more thorough than, you know, an international peer review that might be convened --

DR. FAIRHURST: Okay.

MR. BELL: -- and take place over a couple of months.

DR. FAIRHURST: I was just thinking of the Chairman's constant insistence on being international.

MR. BELL: Well, I may get recalibrated.

[Laughter.]

MS. HANLON: Dr. Garrick?

CHAIRMAN GARRICK: Yes.

MS. HANLON: I just wanted to make a couple comments on some points that came up.

This is Carol Hanlon, I'm with Yucca Mountain Project, Department of Energy and I'm in the licensing branch. And I think Dr. Hornberger asked --

DR. FAIRHURST: Hiding behind a pillar.

MS. HANLON: -- hiding behind a pillar.

And Dr. Hornberger asked, I think, whether or not in the license application plan we would actually have listed the acceptance criteria for the issue of resolution status reports. And in fact, it is not our plan to hae those. I think we've talked to you and we want to make it very clear that we're clearly correlating with the KTIs, the key technical issues, we're correlating with at least four places in that. Probably in the first chapter also in the design description wherever a KTI is appropriate we will identify whether that's appropriate. We'll also identify throughout the TSPA and throughout Volume 4 which in fact will have a matrix which shows where KTI is addressed. However, at the level of detail that we're dealing with in the LA plan we probably will not be going down to the level

that you may be looking for which looks for specific activities or specific tests that will be performed. So we do not plan to have those acceptance criteria lists at this point. We're looking forward to the working draft LA to incorporate them at that time.

So, we're trying to give a correlation, but we won't be able to have the full discussion of how we're going to resolve that. Does that answer your question a little more closely?

DR. HORNBERGER: That helps.

MS. HANLON: And also we've very much looking forward to the NRC's comments on -- on whatever comments they may have on the VA. And, of course, we will forward those and incorporate those into the working draft LA, so we definitely allocated resources and we're looking forward to continuing the prelicensing on that. Thank you.

CHAIRMAN GARRICK: Thank you. All right.

Thanks Mike.

All right. A miracle has happened.

[Laughter.]

CHAIRMAN GARRICK: We have finished a presentation and a discussion well in advance of the allotted time. The committee has a great many reports to consider and matters to consider. It's our understanding that the NEI people -- some of the people will not be available until the scheduled

time of 3:15. So we can't move that up. But what we would like to do is start our session having to do with the preparation of ACNW reports.

There may be a couple of things that are rather straight-forward that we can get out of the way early that I'd like to suggest. One would be the memo of understanding between the ACRS and ACNW on activities of common interest to the two committees and how we're going to work together on those. The other would be we have a draft of a charter for the Advisory Committee on Nuclear Waste which we revise periodically and that period is here to revise it.

DR. HORNBERGER: And it's in my office --

CHAIRMAN GARRICK: So we maybe ought to consider those two items right now because I think they're rather straightforward and we can get them settled.

As far as the division of responsibility between the ACRS and the ACNW the procedure is that we have drafted a document that is proposed that it be signed by both the chairmen of the two committees and basically sent to the committees that identifies those key areas where there is a strong interest on the part of both committees and that within those areas we attempt to come to grips with how we're going to work together or separately on those subjects.

So, the procedure will be that we, the ACNW, will

look at the draft and give our comments. The two chairmen have looked at it and are in essential agreement.

ACRS at their meeting, I guess next week, is it, will similarly review the document and then it will become the basis for our resolving how we're going to handle the subject.

So with that, I think all of you have a copy of it.

Oh, yes, this part of the meeting we don't need to have a record.

[Whereupon, at 1:50 p.m., the public meeting was recessed, to reconvene at 3:15 p.m., this same day.]

AFTERNOON SESSION [Resumed]

[3:15 p.m.]

CHAIRMAN GARRICK: The meeting will come to order.

We are now going to have an informal discussion with the Nuclear Energy Institute on Yucca Mountain, the Yucca Mountain viability assessment. For NEI Marv Fertel will lead the discussion and Marv, why don't you introduce your colleagues.

MR. FERTEL: Thank you, Dr. Garrick. With me today on my left is Steve Kraft who is the director for our high-level waste program. Steve has overall responsibility for all of NEI's activities related to high-level waste disposal particularly as it relates to the ultimate disposal at Yucca Mountain and the interim storage related to it.

On my right is Ralph Andersen who is our lead person in dealing with the regulatory issues related to Yucca Mountain licensing and particularly in interfacing with the ACNW. And I think you all have seen Ralph in the past and you probably will see more of him and probably more of us too if that's useful to you.

CHAIRMAN GARRICK: Good, good. Welcome. Glad to have you here.

MR. FERTEL: Thank you.

CHAIRMAN GARRICK: Yeah, and we've seen Ralph a lot.

MR. FERTEL: We're certainly pleased to be here. Within NEI about a little over a year ago I got responsibility for a number of things including the overall waste program. And as Steve and Ralph and I and some of the others looked at it, what we found was we were focused very heavily on the DOE program. We were certainly focused very heavily on legislation and we still are. And probably with the exception of Ralph who was doing yeoman's work, there wasn't a lot of attention being paid by us to what was going on in NRC's space.

One of the things we thought was we ought to begin to spend more time programmatically both in NRC space and in DOE space and I think over the past year, a little more than that, we've probably done that and we've done that to our pleasure and our interaction with NRC staff and with what we know of the program, I think during the discussion today we'll give you our impression. And we're very pleased with how the staff is working and what we saw down at the center when we visited there during the DOE/NRC technical exchange.

We interact quite extensively with DOE on their issues and we would hope to continue to interact quite extensively with NRC. And as I was telling Dr. Wymer, we certainly welcome the opportunity to come here and interact with ACNW on not only the waste issue, but other -- as I understand it, my colleague Ralph Beadle, who will be here

in June to talk about things like low-level waste and decommissioning and radiation protection safety.

I think that at NEI now we are very involved in a lot of issues. We probably visit with the Commissioners -- at least weekly, someone from our senior management is probably speaking with a Commissioner. And Joe Cowan has emphasized on a number of occasions the value of the industry input to the Commissioners. We continue to do that. We in all honesty haven't been doing that in the waste area except tangentially. I was at a meeting with the Commissioners about three weeks ago on Part 70 licensee issues and did comment to a number of the Commissioners including the Chairman on how favorably impressed we are with the NRC program in waste right now. But we have not made any special visits on waste and I think we probably will start to do that. And, again, I would like to emphasize, we would like to be as helpful to ACNW as we can be and just ask. Again, Ralph hangs around, you know, will give us a buzz and just say there's something that you would like some input on.

I know that Ralph shared with you our annual report and our organizational chart and I'm not going to really talk about NEI except from the standpoint to just be sure you recognize all of the licensees in the U.S. are members of NEI, all of the power plant licensees, all of the

major material licensees. We probably have about 250 members. Maybe a third of those are international members including most of the larger utility companies internationally. Almost all of the fuels facilities and a number of research universities, all of the radiopharmaceutical folks in fact. In fact, they're all meeting in our office today discussing Part 35 issues and other issues like that.

So, from an industry standpoint NEI kind of prides itself on being able to represent the industry on generic issues before NRC or before EPA or before our Congress or the administration depending upon what the issue is. And you should again feel free to look to us as a vehicle or a window into various segments of the industry.

We were asked to talk about the VA today, to DOE viability assessment and what I would like to do is focus on our view of the DOE viability assessment. Both Steve and Ralph can go into greater levels of detail than I can and we are prepared probably to discuss any questions you may have and get them involved.

I'd also like to touch on the pre-licensing process and give some views that we have on that. I know in the note that we sent in we indicated that we might want to talk about spent fuel storage, basically on-site storage. What we'd like to do is kind of defer that, and it's mainly

because we've had a number of discussions with the staff since our note went in. We had a number of discussions with industry folks that are involved in that and there appears to be a pretty significant change in the way things were going and we'd like to get our arms around that before we gave you any insights we have which may be old. So we would rather make sure we're more current and more accurate if we're going to give you our insights, particularly in this case where they would have been pretty critical.

So, before I start, I'm more than willing to keep this real informal, so interrupting me is just fine. I heard when George was going through your report he talked about the King's English written. I couldn't write the King's English and growing up in Brooklyn and going to school in Boston I don't speak the King's English. All the "R"s are there if you do a mass balance which engineers and scientists do. I just put them in where they don't belong and leave them out where they do.

[Laughter.]

MR. FERTEL: So King's English is not my forte, but Ralph and Steve may help.

If there's no questions on anything I've said, I'll start off with our impression on the viability assessment.

CHAIRMAN GARRICK: Well, I think one of the things

that the Committee is pleased to hear is that the industry has renewed interest in the waste field. I think one of the things that I've been openly critical about to my colleagues in the reactor field and in the electric utilities is that once the Nuclear Waste Policy Act of 1982 was written the nuclear utility executives seemed to forget the problem of waste, and I think that was a very serious mistake. Because I think the industry push, industry ideas, industry inspiration is very much needed.

And if on the one hand the industry -- and I'm now thinking more broader than the utilities, really believes that waste is the achilles heel then we've got to start acting like it and give it the kind of totalis and priorities that is necessary to get us through these next few years and finally get to a position where we can look at the public and say, the problem is solved. So, we're very pleased that there seems to be a new consciousness about it. And we hope to get input and feedback from you quite often on this subject. So we're happy that you're here.

MR. FERTEL: Well, thank you, John. I think we are fully committed and reengaged. And I think you're right, I think the industry stayed engaged, but it was in legislative space as opposed to in the programmatic and the technical space. I think people like Steve Kraft stayed involved with all of it, but at times he probably felt like

he was the lone ranger. And I think going down the road now we'll stay more engaged and more so engaged certainly in programmatic whether or not we get legislation because we need to implement the program if we get legislation we need to implement the program if we don't get legislation.

So, I think you'll see us more engaged, more involved, and I appreciate your desire for that involvement and desire for input.

CHAIRMAN GARRICK: Thank you.

MR. FERTEL: On the viability assessment, I know you've been briefed extensively by DOE and NRC staff. Clearly we're looking at the viability assessment for what it is which is a snap shot in time which will provide a reasonably accurate picture of what a design, a cost, and a schedule looks like at that snapshot. What the TSPA or the total system performance assessment looks like. And particularly I think from this organization's view the feasibility or the licensing plan for going forward, and from our standpoint that's a very important effort. Because I think -- and I'll come back to this during the discussion that the submittal of the viability assessment, unless there is some phenomenal surprises that we're unaware of is almost a milestone for a transition from a real focus on just studies and science to a focus on moving towards real licensing of the facility. And I'm not trying to prejudge

the total outcome, it just seems like you get through that and that's where your emphasis starts to move which means that licensing becomes so much more important and the challenges get even greater in that area.

The other thing the viability assessment will do is it's going to inform, basically the national policymakers and the public on where the Department of Energy, and to some degree when NRC does what it will do, where the regulatory body see this particular project standing. It isn't an NRC compliance document. It's not a licensing document and we're always concerned about how it could be looked at. It's not intended to get a license and we don't expect that NRC should review it for compliance sake, but we do see tremendous value of an NRC review focusing on how to get to closure on those licensing-related issues.

It itself does not represent a decision and we don't pretend it does, and certainly DOE doesn't. But it does represent somewhat of a fork in the road for moving down a clear path. Obviously if the site is not viable, it's a very different programmatic approach after this and where do we go. If the site is viable we are now moving down to try and complete the science, move into the licensing phase, and basically try and get a repository licensed and operating in line with the program schedule.

Also, it's not the final snapshot of where the

Mountain is. There will be another snapshot, obviously, when the license application is filed. And given what Lake said at our meeting in Savannah a few weeks ago where it's a monitored repository project, my guess is there will be a number of snapshots going down the road even after licensing is completed.

The thing that the VA can do and we think that the role that ACNW can play, and certainly us in commenting to the staff is that it should have a real meaningful effect on focusing the DOE and NRC licensing efforts. And it should produce real good insights that would allow the scientific program, we think, to be narrowed, and by that we mean focused.

We would hope it would allow some issues to get to closure. And in licensing space we know that NRC and DOE have been working objectively and openly at trying to get to closure on some of these issues. We would hope once they get there they have a process that allow them to remain closed absent some information to reopen them. And it also should allow -- and this is where we think the NRC focus should be on the VA -- the licensing requirements based upon what the licensing plan laid out by DOE is to be firmed up so that DOE gets some real guidance.

Recognize that there is not statutory requirement for NRC to review the VA and we also recognize that NRC

expects that there may be Congressional inquiry as to it, and in all likelihood if I were a Commissioner I would want to know at least what NRC thinks of the licensing plan part of it, if not the rest of it to some degree.

So clearly some review will be required. And we recognize that and we think that that's valuable. We just think that it's got to be done the right way.

We think that the review can serve to help to improve the prelicensing program by, one, enhancing the technical exchange of information between DOE and NRC; and also to move towards more and better integration of the program elements, and I'll come back to integration a number of times during this set of comments.

It provides an opportunity for NRC to share its perspective on what remains to be done for a complete and a well-documented license application.

I think that we need to keep in mind that DOE has never licensed anything. And in this case NRC has never licensed the thing DOE is trying to license. So everybody is trying to break somewhat new ground. And that's something that we shouldn't lose sight of.

I know that some of the DOE folks think they have licensed things and the only thing that I would say is the DOE folks that feel that way worked at NRC. And I've said this to NRC staff, so it's no surprise to John and his

folks. If you've worked on NRC staff, you've never been a licensee. And it's a real different side of the coin.

So, I think the more help you can give DOE and what's expected of the licensee, the better off the application will be, the more smooth and effective the review will be. Because you're reviewing something for the first time, they've never submitted anything.

We think that if DOE does the things or if NRC provides DOE a critical and objective assessment of particularly the licensing plan part of the VA and if DOE does those things that are identified by NRC, it should result in a license application that is acceptable when it get submitted, if they do the right thing and no new information comes up. And, again, we think that that's in everybody's best interest. DOE, NRC, the industry and fundamentally serving our national purpose of getting a waste disposal program in place.

The VA provides NRC a timely opportunity also for some sort of self-assessment and we don't mean that in a critical way of you're doing things wrong.

CHAIRMAN GARRICK: Marv, to get this to maybe the level I think you're interested in and less formal, do you have some views, you or Steve, or Ralph on what some of the things are that the NRC should be doing to --

MR. FERTEL: Sure.

CHAIRMAN GARRICK: -- to smooth the licensing process? Some specific things?

MR. FERTEL: I think one of the more obvious things, John, and this is not a surprise to the NRC staff, they want to do it, is to develop their standard review plan. We think that is an absolutely essential and important component of what would be useful to facilitate the licensing process with the VA providing good input because of what's been laid out and what you see as deficiencies or strengths.

One of the things we'd say in that is when you think of the standard review plan and we know that the NRC staff has done an excellent job in the face of budget constraints of refocusing their program by basically going to a KTI approach. And we think that was very smart, we think it was well done. In looking at the standard review plan process what we'd say is, you need to look at a broader perspective than just the KTIs. You need to be looking at what's required to license the handling facilities, the above-ground facilities which are not part of the KTIs because they're all looking at post-closure items.

So we think that one of the things the NRC staff can do to help the DOE is to step back when they get the VA, look at what's in it, look at what's been dealt with effectively, what DOE thinks they still need to do and then

have a standard -- have your comments go back which helps DOE understand, yes, this part of your document is really good. We agree with you, and these items would look like they're in great shape. We think that for these other items you still need to do these kinds of things to satisfy us and there's a whole bunch of dimensions maybe they've forgotten because they too may be focused on certain areas that had been the ones that had been hot and heavy.

So we think the real important things is not like a Part 50 licensing where, you know, we've gone through it, you know, 107 times and I know what goes in or I'm pretty sure I do. This is going to be a case where, gee, I didn't know I had to put that in this and how do I put it in. So we think the standard review plan becomes a very integral output from the NRC staff after they've looked at the licensing plan that's part of the VA and that becomes an input to how the DOE can respond.

Ralph, do you or Steve have something you want to add to that in particular? Steve?

MR. KRAFT: Well, reserving the right to some future date provide you a specific list of those items, it has been my observation that there's a need to close issues and hold them closed. And part of that may not be necessarily we all agree on either side of the table that X equals 29 and Y equals 35, but that we agree on the pathway

to determining those answers and doing it in such a way whether it's through the commitments made by NRC, and DOE, in the course of the VA and its review or in some other manner for doing that.

There have been some attempts at doing that. Issues like these big -- or the list of big issues, severe erosion and groundwater travel and all that sort of stuff that have associated with them the need to first determine what are the ways we are going to analyze them.

A good example without going through the details is the recent working paper in Science Magazine. We now know there's another way to look at accumulation of strength. What ways are we going to use? What is the acceptable way we're going to do that? What's the way NRC is going to ask it to be looked at.

Another good example is when we were at the technical exchange in San Antonio. I was really -- I was very impressed with the extent that DOE is taking TSPA modeling. It is frankly beyond anything we imagined it would turn into. I mean, it is so complicated and so complex now there are submodels that won't add up and they have to have basically simplified models to add to get to the top model. And then NRC is trying its best to envelope it with some conservative boundary kind of modeling which is appropriate to do. But how those two fit together I don't

think is too well defined what NRC is going to be looking at.

They're all part -- this is all part of the same issue. How do you get an issue closed and how do you hold it closed once it is closed? Absent some additional information.

MR. FERTEL: Yeah, and absent new information that causes you to open it up again.

I think in the same context one of the things that's probably important when NRC writes up their review of the VA is clearly most things that NRC turns out not just in a waste program, certainly in Part 50 space, or Part 70 space, the intent is not to write a whole document about this is good and it's closed. It's here's what's missing or here's what's wrong. And I think we need to make sure that the NRC document that comes out on the VA it's recognized that the audiences that will read that are much broader than just the DOE AKRIN program.

Within DOE the technical review board will be looking at that and they'll be looking at it from what context is NRC saying there are problems or there's strengths. Clearly the Congress might be looking at it. The public will look at it, Nevada will look at it, the industry will look at it. And one of the things that would be most helpful when it goes to Steve's closure issue is for

whatever you say to indicate where you think things are good. It's not just where are there things that need to be improved. Because if I'm going to write a license application and 50 percent of what I gave you looks real good to you, I ought to know that as opposed to only the places where you feel there's holes and there's more additional work that has to be done.

So I think -- and I'm not saying that because NRC might intend to just paint the negatives. The inclination is normally to lay out what's missing, what still has to be done. And what we're saying in this case, it's real important to lay out the full picture.

MR. ANDERSEN: I think a couple of things that I would add in response to your question, John, first and foremost the viability assessment will cover the entire landscape of the facility, not just the post-closure issues. And I think it's an opportunity for the NRC at large, not just the division of waste management to take its first shot at how they're going to integrate all of the programs in licensing Yucca Mountain. And this gets back to the above-ground facilities and also issues that won't fall under a risk-informed regulation. Retrievability is a very simple one.

But, you know, our view is there's a lot of efforts going on within the NRC that will all have to be

brought together at the time of the licensing far beyond what is defined within John Greeve's office.

MR. FERTEL: Ralph just made an interesting comment that -- let me just expand on. He said some of those aren't risk-informed regulation. When we think about Yucca, we think in terms of risk-informed, performance-based. When you think about some of the above-ground facilities they are probably more deterministic. When you think about licensing NRC has never licensed anything in risk-informed, performance-based space.

I mean, Part 35 is attempting to do -- Part 35 right now is a regulation the Chairman and others are looking at changing rules and we've got the maintenance rule. But really the licensing of the repository will be the first risk-informed, performance-based licensing effort NRC has ever had. And it's not straight that way either, it's going to have to integrate deterministic licensing when you pick up what Ralph just said and recognize that your licensing a multitude of different activities and facilities all of which need to be looked at maybe slightly differently. So it's really a very unique licensing exercise.

MR. ANDERSEN: I remember, John, that several meetings ago when spent fuel projects office was up talking more explicitly about the on-site storage issues you raised

that question then as to whether opportunities had been missed to go down a risk-informed road for licensing on-site storage. And it struck me at the time that this is all going to converge at Yucca Mountain. So, I mean, you're going to have different rules and requirements coming into play. And it's that integration that I think the viability assessment provides an opportunity for the broad NRC staff to take a look at and begging to figure out how they're going to do that.

CHAIRMAN GARRICK: Yeah. And I think some people think that the position that the Yucca Mountain project is in is an advantage. The problem that the reactor people are having now is how to convert the transition from the traditional way of licensing to a more risk-informed way. And the frustration with the industry is that contrary to the PRA policy statement it's adding burden, not decreasing burden on the part of the licensees to accommodate the transition -- license in the Yucca Mountain, we're at least not burdened with that. We're going to be put to the test immediately as to how to do this. And I think that there will be some advantages taken of that because in principal, at least, they won't have to do it both ways.

MR. FERTEL: You have the opportunity to have at least a partially clean sheet of paper to write it up right the first time. But you do have stuff on the books that do

affect the licensing of some of the portions of the project. But it is a time, again we look at the viability assessment as the point in time where you really are entering the licensing phase and where NRC can really take a tremendously important leadership role in laying out in pretty comprehensive detail the path forward for DOE to follow. Because we are convinced that otherwise they won't know what to do.

I think the other aspect on just the closure points that Steve is making too are important that somehow historically issues never stay closed. So we need to figure out how to keep them closed, but we also need to recognize that historically you didn't have the relationship between licensee and regulator that NRC and DOE have had in this prelicensing stage.

And, again, we're very impressed with it over the last year the interactions we've had on both sides. And we're impressed not because they're getting answers we like, we think they're working very objectively and the scientists are doing real good work. At some point they're going to change that mode and go more into the conventional licensing mode once that application is filed. And even preparing for that transition is going to be very important. Because right now it's very easy to have these technical exchanges, very productive, and very open, and this is all done very

professionally, it's done openly, there's been public involvement, there's Nevada involvement, there's industry involvement. But once the application is filed the dynamic will have to change.

And, again, I'm sure that John, and Margaret, and Carl are thinking about that, but it's real important that they not only think about it, but that the DOE side understand how that change is going to occur and how we're not going to lose any steps in working together when that change occurs.

MR. ANDERSEN: Perhaps a more mundane level I also think that this would be an excellent opportunity in reviewing the viability assessment for NRC to reevaluate its resource needs through the period of licensing. I think they'll have a much better feel for what those -- what the true needs are going to be both internal to NRC at the center.

Earlier today you talked about external contracting at the center. I think some of those needs are going to become very apparent merely to do the review of the VA. It's quite different than doing the segmented reviews that have been done in the past. And, again, I want to suggest that those resource needs extend outside the division of waste management.

CHAIRMAN GARRICK: Is industry going to do

anything with the VA voluntarily or otherwise?

MR. FERTEL: We'll certainly internally review it. I doubt whether we would publish an independent assessment of the VA, but I'm sure that we would communicate to DOE and to NRC any thoughts we had on how to go forward to achieve the licensing process and strengthen the project overall. Right now we don't intend to necessarily publish a critique of it.

MR. ANDERSEN: I'll mention a fourth important player of our team was here at the last meeting and not at this one, and that's John Kessler at EPRI.

MR. FERTEL: Right.

MR. ANDERSEN: So when you say the industry, the collective industry certainly will be looking at it. And as John mentioned to you at the previous meeting, he's positioning himself to do that.

CHAIRMAN GARRICK: Yes. Yes. I'm pleased to hear that you're collaborating on that.

MR. ANDERSEN: Oh, yeah, we see each other frequently.

MR. FERTEL: Just on that, John, is there something you think industry could do that would be helpful to you?

CHAIRMAN GARRICK: Well, you have noted some very interesting issues associated with the licensing process and

I agree with you that once there is an application filed that things may change quite a bit. And I think that the experience, the experience that industry has with licensing could be extremely valuable in this whole process if somehow it could be brought to bear. And so ways in which you could do that, I think would be important. Because it is right now even though there's high sensitivity especially with the Office of the General Counsel about keeping separate DOE and NRC, there is nevertheless a rather collegial kind of relationship which I think is frankly very healthy and enhances the communication a great deal. And for a while, at least, this problem is being approached in a more scientifically traditional fashion than in a manner that makes it very difficult to deal with the issues and benefit from each other's thinking.

So that probably is going to change. And I guess anything that industry could share with NRC and DOE to facilitate that change would be a major contribution.

MR. FERTEL: Okay. Well, we'll certainly be looking at the viability assessment with that in mind and we certainly won't hold back any thoughts we have on what can be done to make that transition.

Steve, do you want to touch on the technical aspect of improving the safety standard from --

MR. KRAFT: Oh, I think Ralph is probably better

able than I except just as an introduction that I think probably the most important thing NRC can do and you're on the road to doing that is having a regulation which includes a radiation safety standard that is going to last long enough for NRC and DOE to actually use it to do licensing.

I mean, you know, there's so many -- and I go back in this program before there was this program. And I don't know how many versions of that EPA standard we all looked at and commented on and took them to court over and everything else we did, but it is still not settled. NAS reports notwithstanding, it is still not settled. And I think that the pathway that NRC has embarked on now, having read appropriate SECY and SRM for Part 63 is exactly in the right direction. And that's got to get done. And I think what will come out of the VA probably the most telling instructions to the staff in the SRM is to practical and implementable because that speaks to the notion that NRC wants -- believes that you need to have a repository in this country for ultimate health and safety. And then you're going to write a regulation that is going to be practicable and implementable, not one that can't be met. And I think that's an extremely important point of view.

And that's probably the single most important thing that the staff can do, read the VA, understand the VA and that will tell you what is practicable and

implementable. Now, I'm not saying you write a standard that makes Yucca Mountain successful, but you're going to have to inform the writing of that standard with Yucca Mountain in mind since it's tailored to that site.

Ralph, do you want to comment?

MR. ANDERSEN: Yeah. First of all I'll expand on that a little bit. But if one takes the technical basis from the National Academy of Sciences issued to support the radiation standard, it would seem to me that the VA provides an opportunity to reassess that technical basis. Because knowledge will have advanced significantly since the time that the NAS committee issued that report. And I think that's where that's of great value. It's really redefining the technical basis for the standard to assure that it's practical and implementable. It's not adjusting the standard to fit Yucca Mountain. And, in fact, I've already been looking at the NAS report in that context. I can hardly wait to get the full viability assessment.

I think that overall the timing is extraordinary, that the staff has a strategy for doing a rulemaking and has approval to proceed with that. And suddenly right in the midst of that they get to what in my mind would be any rulemaker's dream which is to get a mock submittal against which that rule will be tested. So I think that's of tremendous value for them to take the concepts that they've

described for the rulemaking and to test those out on the viability assessment again with the thought of practical and implementable.

Some key things that I see is, I think it will help them clearly identify what are the relevant site characteristics and design features since their intent is to move away from the Sears Catalogue listing in Part 60. So I think narrowing that down will be greatly enabled by a review of the viability assessment and their own review of it.

I think additionally that it may help them better come to grips with how they're going to handle the issue of defense in depth with regard to the multiple barriers in the absence of setting specific criteria. You know what I mean? I've read a lot about it, I've heard a lot about it, and I know a lot of people are thinking a lot about it, but it's another one of those issues where this will be a first-time effort.

And, again, I think the VA and their review of the VA gives them a real opportunity to test their concepts out and see if they get meaningful conclusions when they do that. Because from my view, and I don't mean it critical, I really admire the concept that they're pursuing, but it's still kind of mushy in my mind as to how it all comes together. But once you understand the interrelationships

and the uncertainties that's fine, but what do you do with that information in terms of a licensing decision. How much uncertainty is too big? How much defense in depth is deep enough? You know, I think it helps them begin to engage that effort.

And then quite obviously it provides the opportunity to begin developing those assumptions that they're going to build into the biosphere and critical group definitions. I mean, that certainly will be a part of the viability assessment. I recognize that the NRC has been working on that at great length with DOE. But, again, I think this is the litmus test of whether they've got the necessary information to do the rulemaking in that regard.

Those are just some examples, but I -- again, I can't stress, if I were a rulemaker this would just be a dream. It's a grand opportunity.

DR. FAIRHURST: Do you have any specifics of where you think the science has advanced significantly since Tim's report?

MR. ANDERSEN: Well, I think that one of the areas where one might begin to better question is in the timeframe issue. To better understand whether the uncertain -- the sort of stock phrase, depending on which side of the coin you're on, is that the uncertainty blows up so great it's meaningless. I think that's a real clear example. And I

appreciate what the Academy did, it's just that they didn't have in hand all of these assessments and uncertainty evaluations that now people will have in hand to look at. So I think they can answer some of those tough questions better about peak dose and reasonable timeframes and so forth as to whether that will fit.

Again, the criteria, Dr. Fairhurst, is ultimately that the standard has to be practical and implementable. So it's a great opportunity.

MR. FERTEL: Yeah, it's not a criticism of where the Academy ended up as much as --

DR. FAIRHURST: Oh, no, no, no --

MR. FERTEL: -- progress and the knowledge --

DR. FAIRHURST: The specifics.

CHAIRMAN GARRICK: That's all right. You can criticize him, he was on the committee.

MR. FERTEL: I know.

[Laughter.]

DR. FAIRHURST: We appreciate that very much.

DR. HORNBERGER: We criticize it all the time.

[Laughter.]

DR. FAIRHURST: Some inside stories, too, but --

[Laughter.]

DR. FAIRHURST: -- you can read if you read some of the parts of it.

MR. ANDERSEN: I want to give credit where credit is due. Dr. Carter is the person who in conversations with him has helped me think hard about this relationship with the VA, yes --

DR. FAIRHURST: Mel Carter.

MR. ANDERSEN: Beg your pardon?

MR. FERTEL: Mel Carter.

MR. ANDERSEN: Mel Carter.

[Laughter.]

CHAIRMAN GARRICK: Margaret, I want to invite you or any of your staff to pitch in on this informal fireside chat if you're so inclined.

MS. FEDERLINE: Okay. Let me ask Mike Bell to join me up here at the table.

CHAIRMAN GARRICK: I guess it's legitimate to make it as informal as we'd like.

Ralph, you were giving us some of your points.

MR. ANDERSEN: That's pretty much it. I intended only by example rather than an exhaustive listing. But, you know, the idea is it would be a shame if when all was said and done if the only activity on NRC's part, and I know they would go beyond this, was merely to offer constructive criticism to DOE. It's a great opportunity for self assessment and in our reactor business that's just the way we always think. So that's why I think they could take

that.

CHAIRMAN GARRICK: Yeah.

DR. FAIRHURST: Do you have any ideas about how one should deal with human intrusion?

[Laughter.]

DR. FAIRHURST: You're actually talking about things and events --

MR. KRAFT: Well, I'll tell you what we think about human intrusion.

MR. FERTEL: Steve did this earlier too.

[Laughter.]

MR. KRAFT: I've got the sound bite down.

MR. FERTEL: He's got it down, so we'll let Steve do this.

[Laughter.]

MR. KRAFT: We know a whole lot more about predicting geologic events in the future than we do human behavior. So to say that we can sit here today and project 10,000 -- 700,000 years into the future is in fact probably not something you can do.

So our view, and we made this clear when we submitted our recommendations to Tim's group is that the adoption of what we referred to at the time as a "building code standard" that you design certain features into the repository to make it as resistive to human intrusion such

that those intrusions end up in violating the standard that you set is possible. And you do the best you can do and that's about -- I hate to say that's about all you can do. Because if you start trying to include probabilistic assessments of human intrusion in the future you will be chasing your tail forever, and you will never come to a conclusion on how to predict human intrusion.

Let me take it a bit further. There is always this underlying concept in every regulatory document I've read and every discussion that I've had that if we remain a technologically advanced and advancing society, then there's no problem. We will remember what's at Yucca Mountain, or if we forgot, if we ever go back there we'll figure it out. But there's always this underlying belief that there's the possibility without saying what that probability might be that there will be a cataclysmic event that will return man to the caves. That we need to protect future generations living in those caves who will become once again hunters and gatherers and all the things that we've looked back on our own past and determined -- and see what we -- to get to today.

Now, in terms of protecting the cave dweller of future from contamination of groundwaters that they will be drinking and growing grains in and what have you, that is accomplished through the design of the repository and that

activity. Because what you're talking about is whether or not those individuals who will have the capability of intruding into the repository and not knowing what they're picking up. Well, if those -- you know, future society developed the technology to intrude into that facility at some distant time in the future why do you believe they would not also develop the other technologies along the way that will allow them to know what's there? We certainly did as we developed to this point.

The concept that Leo Duffy, former Assistant Secretary of Nuclear Energy during the Bush Administration, used to like to say, he constantly has to explain and deal with the intelligent neanderthal. The person capable of drilling 3,000 feet into the crust of the earth without the intelligence of knowing what he's pulling up. And it just doesn't seem to make sense because it didn't apply to us as we came as we developed. So that's why we are comfortable recommending that this concept of a building standard where you create -- and I'll repeat it, where you create conditions that minimize the possibility of intrusion as much as possible, but you do not attempt to predict the human behavior.

Oh, and there may have to be a policy determination in this country to make that kind of work that way. And that is why that language is included in the

legislation pending before Congress.

CHAIRMAN GARRICK: Charles, I think the Academy came down with about the same view.

DR. FAIRHURST: Yeah, but it's just interesting that this issue is brought up internationally and everybody is trying to deal with it. You saw, that was one area where I don't think scientific opinion -- scientific knowledge has gained very much since the Academy put out its report. But it's interesting to see. I mean, we said it was scientifically without merit. I don't know what the exact words were but --

MR. FERTEL: It's interesting we're worrying about that for something that's a deep geologic repository, but not for landfills or chemical dumps that will still be there at the same time and probably a hell of a lot more accessible.

DR. FAIRHURST: You don't have to persuade me.

[Laughter.]

DR. FAIRHURST: I'm saying that there is a perception and there's a repository very close to being licensed, well, human intrusion is the only criterion. So while you're in a political climate like that you're able to just say, get away. This is nonsense. I don't know if you all -- whether you can pull it off.

MS. FEDERLINE: Could I just add something here?

CHAIRMAN GARRICK: Yes.

MS. FEDERLINE: One of the concepts that's being explored internationally is the idea that we're designing a reasonable test for repositories based on current information, what we know today. And I think that's a very reasonable standard. It's the way we make decisions every day in life. You know, we don't sit and try and predict what's going to happen a hundred years from now and base our life insurance on that. We make reasonable predictions based on what we know.

DR. FAIRHURST: Well, in fact, this is what was in that report. They examine what we think would happen with a single intrusion and somewhat along your lines see how you can design so that that does not result in anything significant.

MS. FEDERLINE: Right.

DR. FAIRHURST: And if you've done that --

MS. FEDERLINE: You've done your reasonable test for society.

MR. FERTEL: I think, John, on the discussion we were having a little while ago on specific examples and sort of relating it to your question about our review of the VA, clearly after we look at the VA we would welcome the opportunity to come back and maybe give you our impression of more specific examples that we see either in licensing

space or in scientific technical space that we think it might be worthwhile if NRC staff has not picked up on those which I tend to think they probably will maybe they should consider.

CHAIRMAN GARRICK: Yes. Yes. I think that would be a good idea. I think we're all going to try to get as much out of the VA exercise as possible in spite of the lack of an official requirement for the NRC.

And it was even referred to by one DOE person in the corridors some months back as kind of a trial license application. And so I think it's an extremely important exercise and will be a strong indicator of what we're going to see over the next few years.

MR. FERTEL: Just another comment on Ralph's comment about resources. We think that probably is very important. It's probably important on the DOE side too and we'll probably share our views with Lake and his folks on that. But clearly for NRC staff to look at the resource requirements as you move into the licensing mode. And in the context of all the licensing activities that the staffs who are involved in, as the guys are saying, it's broader than just Margaret and John's group as you begin to look at this. So we think you should look hard at that and I think that right now you actually have NEI support for the resources and budget request that you all put in for the

waste program. We're very supportive of that. Our testimony supports it and certainly our discussions on the Hill with Hill staff and Hill members support this.

There's other parts of the NRC budget that we have a problem with, but's not the waste problem.

CHAIRMAN GARRICK: Yes. Yes, I understand.

MS. FEDERLINE: Could I just clarify what you mean by "other pieces"? Because as currently envisioned surface facilities will be licensed under Part 63.

MR. KRAFT: Well, is a Part 63 staff going to do that or will you in essence subcontract out Part 72 staff, or are you going to bring in Part 72 staff?

MS. FEDERLINE: No.

MR. KRAFT: So you're going to create your own capability inside Part 63 to do --

MS. FEDERLINE: Well, we already have our own capability because we've developed a staff technical position on surface facilities.

MR. KRAFT: But, Margaret, the surface facilities are going to be closer to in infancy than they are to a repository. And that's what Ralph is talking about is that there are other --

MR. ANDERSEN: Yeah, I was specifically referring to the receipt, the transport, and fuel handling aspects which I guess I had envisioned would draw heavily from the

central NRM storage standard review plan and the spent fuel projects office expertise.

MS. FEDERLINE: I think it's true that we will draw on the standard review plan. I think that's very true. Our plan is to piggyback on top and we also for preclosure are working -- I don't know whether you know -- with DOE on a binning concept of preclosure issues focusing on the use of accepted industry codes and standards and looking at the more critical unknown issues, retrievability, and those sorts of things as the issues that we'll be focusing on most highly.

MR. FERTEL: But what you're saying Margaret is that the licensing of the receipt facility which again looks very much like a PFS facility probably would be licensed under Part 63 using resources that report to you and John, not using resources that report to Charlie or other folks.

MS. FEDERLINE: Well, that's the current plan.

MR. FERTEL: Okay. Yeah, our only point is that if the resources are elsewhere you really need to look at the integration to be sure that they're available. And we mean for both things. We may come back in three years and tell you you're using resources that should have a higher priority in something else, I don't know. But we want to make sure that you're looking at it in an integrated way if you're borrowing resources from other programs.

MR. ANDERSEN: I consider that very good news. I was just curious, I wish I had asked you this question previously, but in doing the VA review as you envision it will be requested by the Congress or some other person, were you envisioning limiting that only to the post-closure issues?

MS. FEDERLINE: That's our plan is to focus on post-closure. We are reprogramming SIMM resources in the next fiscal year to begin to work on pre-closure issues, the critical pre-closure issues.

MR. ANDERSEN: Okay. Why don't you do this.

MR. KRAFT: One matter that the conversation kind of walked away from the VA in itself. And one matter that I would like to address is that it seemed to me that having been in on some of the early discussions with DOE when the VA kind of began developing this as a concept, and I think you probably know this history, but it started out when Congress reduced the budget for the program and DOE was faced with this notion of completing $900 million worth of work and having nothing to show for it except a couple of holes in the ground. And they began asking themselves the question as all good project managers should, well, what can we actually accomplish for the amount of money available to us and how can we get there most efficiently?

I remember an old manager of mine many years go

when I was in project management said something to me about when you get your budget cut you figure out what you're really about. And that is certainly what happened to DOE. And I recall very early conversations with Yucca Mountain project staff about what they were going to do along those lines and began to emerge this concept of what we now call the viability assessment. And of course you know they searched the lexicon of the regulations and the statutes to find words that were not used any place else so they bore no relationship to existing terms of art, or statutes or anything else. And what they meant was, an internal business decision that a business might make. You know, look at a project and say, is it worth making that next round of investment? Is it worth taking it to that next level?

And that is still fundamentally what this is. Can we convince ourselves -- can DOE convince itself in its internal decisionmaking it is worth taking that next step? And I remember former director, Dan Dryfuss explaining to me, he says, "Steve, the way you'll know a program is viable after I read the book is the next day the program is still going." That's what that's going to mean. And I still believe that's what this is supposed to be about.

But it has had a lot of other stuff added to it. They are now adding alternatives to the design. They are

now adding alternatives to waste packages. They had to come up with their own -- and performance measure because there was no performance measure out for them to use. Others are looking at this and saying, oh, you know, this isn't really a duck, this is a cow, from my perspective, when in fact it's really a duck. And what I'm getting at is that, if you think about what this is, it is not a license application. It may be a surrogate for one that could be useful for learning experiences, but it is not a license application.

It is an internal DOE document for them to decide whether they're going to take the -- what does that require. That requires a single case that meets the grade. It doesn't require a whole lot of alternatives. And that case isn't necessarily the case they offered for licensing. All they have to do is prove to themselves there was one way to do this job that meets their internal notion of what is required on a public health and safety basis, a financial basis, the ability to get it licensed, the ability to design it down the line.

And I think what's happening is that there's a lot of other forces around in the system that are looking at this as something that is beyond that and demanding lots of alternatives, why aren't you looking at this, and why aren't you looking at that. When I know for a fact what DOE is doing -- Margaret used the word "binning", I think that's a

very good term for what they're doing here too.

As the engineers and scientists, and we all are one of them here, comes up, oh, they look at it. Oh, wait a minute, what if we did it this way over here? They say, great, stick it in the LA bin. We'll deal with that next. And that's where all the churning is going to happen in terms of the alternatives. And I've been saying this to as many groups as I can because I would like to get the expectations in place as to what it is this document really is going to be. And that that document may not look at the alternative that you personally like, the one you believe is the right one, and the doesn't mean it's not a good document. What it meant is that's an alternative that they can consider later. Because the purpose of this document is to convince DOE internally it's worth taking that next step.

MR. ANDERSEN: I guess I would like to add something to that thinking back in reactor licensing space. I see that the VA provides an opportunity through this reference design concept for the NRC to baseline its own review. And it makes a lot more sense to get that done however imperfect it might seem to others so that then NRC has something to work off of to evaluate alternatives.

I kind of worry that we're going to get caught evaluating alternatives before we even understand some form of a base case that we can refer things to --

CHAIRMAN GARRICK: Ralph, when you guys use alternatives what are you thinking of?

MR. ANDERSEN: You mean within reactor space?

CHAIRMAN GARRICK: No, within the viability assessment?

MR. FERTEL: Alternative design concepts.

MR. ANDERSEN: Yeah, I'm referring specifically, for instance, whether to use backfill, whether to use --

CHAIRMAN GARRICK: So you're thinking of the details? You're not thinking of global alternatives?

MR. ANDERSEN: No. Details and design space.

MR. FERTEL: Alternatives to repositories as a global alternative, for example? Or alternatives to some other --

MR. KRAFT: Well, no, I think it's pretty much settled in this country that we're going to do deep geologic disposal absence an ability to find a site. You'd have to change the policy of the country to do otherwise.

MR. FERTEL: Well, John was just asking what we were talking about and we're talking about details.

CHAIRMAN GARRICK: But alternatives could also mean alternative geologic sites.

MR. FERTEL: Right. And we're not talking that here.

CHAIRMAN GARRICK: And you're not talking about

that?

MR. FERTEL: We're talking details in the design process and the defense indepth concept and --

CHAIRMAN GARRICK: Yeah, okay.

MR. ANDERSEN: I think my comment is coming -- we talked earlier about division of labor. So I tend to view the high-level waste program from industry looking over the shoulder of NRC rather than industry looking over the shoulder of DOE. So for instance when I had an opportunity to glance at the recent report from the technical review board in which it recommended some other alternatives might get folded at the last minute into the viability assessment. I just -- I think that would -- looking over the shoulder of the NRC, I think that would be an unfortunate decision to go ahead and do that because I think the NRC would lose a lot of the opportunity to focus on a base-cased design from which then to work towards a standard review plan and licensing.

I'm getting a sense that people are misunderstanding what this VA is. It represents knowledge as of a certain date, not an open invitation to try to invent new knowledge in a short period of time. So we'll probably make our input to everyone that we can that we think that probably wouldn't serve the process very well.

MR. FERTEL: Yeah, I think Steve characterized it

right. We would like to create the expectation that this ought to look at a base case which may or may not turn out to be the actual one that gets submitted for licensing assuming you move down the path. But it's not a case of looking at 12 different designs at this stage to see which one you might like better or not like better, or how you would license this one versus that one.

DR. HORNBERGER: But it seems to me that we're also at a point where we can't be speechless about this. You know, when the Swedes came out with that KBS-3 plan with a 10-centimeter thick copper canister that you could look at that as a proof of concept too which is what they did as a base case. But even at the time nobody believed that they were really going to do that. It was simply to demonstrate that it could be done.

DOE is well beyond that and to the extent that the base case has to say something about being the least considered a feasible --

MR. FERTEL: Well, I think, as Steve said, they won't submit it if it's not feasible.

MR. KRAFT: No question about that. But --

MR. FERTEL: It may not be optimal.

MR. KRAFT: Exactly right. Exactly right.

MR. ANDERSEN: That's sort of where I'm coming from too, George, is that there is a time constraint. If

everyone does what they're supposed to do, then in October this report will be sent to the Hill. And the schedules the DOE has put before us over and over again stress that the door for innovation pretty much had to close about April to accomplish that. So I'm just thinking, it's an inopportune time to suggest expansion of scope.

MR. FERTEL: But on the concept of innovation there's probably something that we would encourage NRC to think about, and that's probably innovation and licensing which might be looking at phased licensing approach. What could we do to start construction sooner? What could we do which would probably be our greatest motivation to receive fuel earlier. How could Part 63 be written to facilitate that and permit that?

So I think while we're -- we don't want to stymie innovation and design, we're just saying that for the viability assessment of work you ought to freeze it and then be innovative as you go down the road. I think in the licensing space we would say think innovative right now because you don't want to lock yourself into a path in rulemaking that doesn't permit you to do something that two years from now you say, boy, I wish I were able to do this. But the rule is already passed and I've kind of locked myself in because I didn't give myself enough flexibility.

MS. FEDERLINE: Could I just add one point on the

design? I know when I met with ACNW about two meetings ago the staff discussed this. We're very concerned about this too and we're concerned about it from the perspective of a transition from pre-licensing to licensing as you were just talking about. We believe that it makes sense to make changes in the design through a logical design control process where the decisionmaking process will be apparent once we get to licensing what the strengths and weaknesses were of adding additional aspects to the design.

So although I hate to find myself agreeing with the industry, since I'm already on record two meetings ago I will.

[Laughter.]

CHAIRMAN GARRICK: That's all right.

MR. KRAFT: We feel the same.

MS. FEDERLINE: I knew Steve would say that.

[Laughter.]

MR. FERTEL: I think, John, those are probably the guts of the comments we wanted to make, but we certainly are enjoying the dialogue, and if there's other questions or dialogue, we're here at your convenience.

CHAIRMAN GARRICK: Well, I don't know. I think that the parallels and the differences that we're talking about between the waste and the other licensing activities have been an important part of this discussion. One of the

things that I'm quite encouraged by though that might offset some of the problems of this being a one-of-a-kind, first-of-a-kind in many respects, not just with respect to the facility, but with respect to the whole process of licensing the facility, is the fact that there seems to be a pretty rational and deliberate effort to be prepared when the license application is finally submitted.

I don't know if you were here or any of you were here this morning when we were talking about the total system performance and the performance assessment activity. I can imagine had we been able to do something like that prior to the first reactor license life would have been ever so much different and I think simpler. So in spite of its uniqueness and in spite of the tremendous obstacles there does seem to be some activities going on that are going to enable us to be efficient. I wouldn't say take shortcuts, but be efficient in coming to grips with some of the licensing issues. And I just hope that spirit of enthusiasm and interest continue.

And I think the industry is very important in this whole arena as a stimulant. One of the things that I don't particularly like about the waste business is it's not competitive enough. It's kind of a captive business to the Government. Industry plays a role, but primarily in the context of captive contracts and so there's a real lack of

competitive fire in the process and we somehow have to find a way to compensate for that. And that process is further inhibited if industry just sits on the sidelines as they have from 1982 to about 1992 and expects the Government to get the job done.

So I think that you hold a very important card in hand in keeping this thing moving and doing what you can to stimulate the DOE, the NRC, and all of the contractors to move ahead.

DR. FAIRHURST: We're certainly committed to doing that, John, and I think you'll see us doing more and more of it.

CHAIRMAN GARRICK: Yes. Yes. Well, I'm encouraged to find a few utility executives that three or four years ago showing no interest in the waste field that are now extremely active and involved and interested. So I think there has been progress made in that regard. And part of that may be as a result of NEI's activities as well, I hope so.

Comments?

DR. HORNBERGER: I wanted to address a question. I think the term "defense indepth" came up a couple of times and it was more the charge to -- I think Ralph said that the review of the VA would provide a test for how things like defense indepth would work. But I'd like to throw this back

to you because as you probably know, we've wrestled with this issue of how multiple barriers and defense indepth is to work and you people clearly have thought about this. So how do you see it working in terms of the waste -- of the high-level regulation?

MR. FERTEL: I think there's probably a diversity of views, not necessarily not congruent, but a diversity of views. And I think that clearly defense indepth and anything nuclear makes sense. I think that the industry has subscribed to it in every space I know whether it's materials or it's reactors and we subscribe to it in waste. I think that the balance that's required is to understand how much defense indepth you need for the risk that you're trying to deal with. And I think that's where when Steve refers to the alternatives that you're looking at, I know we could design a defense indepth that would look today impregnable. And at what cost would that be for what risk involved?

And I think that what we would say is that as the DOE moves down the road, what they'll present later this year will be something that we expect will work, will meet the standard as they envision the standard, will involve some defense indepth concepts and certainly TRB and NRC and others are looking at strengthening I think what DOE is looking at. And I think DOE Is probably looking at

strengthening it too. I think the challenge will be to keep your eye on what you're protecting against as you do that.

In the most recent TRB report they refer to the fact that while they don't truly see any added safety value there may be a value of dealing with the perception of safety for just doing full testing on all casks and things like that.

Personally, from a public policy standpoint, I don't find that particularly helpful. If there's not incremental reduction in risk that necessitates the costs and if there's no increased value to safety, saying I'm going to deal with the perception, I can probably deal with perception a lot less expensively than saying I want to fully test all casks. And I think that when we look at defense indepth for the repository design it's got to take on what was the term that Ralph and Steve used before, practical -- or the Commission really used a test which says, okay, what are we getting for this? And particularly if we're going to continue to monitor.

So I'm not sure we have an answer that says, this is the design that satisfies it. I think we have a philosophy that says, defense indepth always makes sense in the business we're in, but defense indepth that looks at it in a prudent way from a risk management standpoint is how we should approach it. We know the technology will get better

with time. And Steve, do you want to --

MR. KRAFT: Well, I think that completely consistent with Marvin's views is the use of the TSPA as a management tool. We proposed many years ago with EPRI the use of a TSPA type of activity that DOE had not yet begun to consider early on in the project. And we didn't propose it as a licensing kind of activity, we were looking for a management tool. Something that they could use to assess their activities to determine which ones are truly important and are non-important. Okay.

That was fundamentally the problem with subsystem performance standards. That you end up focusing on things that in reality of the TSPA may not have been important. So I think you have to run the TSPAs and look at where spending the extra time, money and resources -- and I don't know that I can come up with a concrete example, but -- and this is probably wrong, but going to using your example, going to 10-centimeters of copper compared to what you're planning on now, you've got to run the TSPA case and say, is that really going to get me out here in the biosphere of the reduction that that looks like I need to get to make that worthwhile. If it's not, don't bother trying to defend indepth with that matter or with that item.

At this point I don't think we can predict what those are. But the TSPA must be used as a management tool,

not just as an analytical tool, not just a regulatory tool, but a management tool. And I think DOE hasn't actually been doing that. You look at a proposal from any particular scientist to look at a different design or a different study, and you look at its contribution in reduction of dose through the TSPA. And if it looks like it's going to be a big contributor, then great, you do it. If it doesn't, do bother. And that's -- that's where I think NRC's views can be helpful. That's certainly the work that EPRI has been doing that kind of shows how that should operate.

MR. ANDERSEN: Actually, picking up on that theme, one of the things that struck me in John Kessler's presentation last month was how he was able to graphically display stripping away various barriers and the effect of that. What struck me at the time looking at that is that the VA itself would provide an opportunity to begin thinking about how to display defense indepth that that's going to be a responsibility for both DOE and the NRC. Also it will be an opportunity for the first time to review someone's description of the defense indepth. I mean, this will give a total product for NRC to look at in the context of getting ready for rulemaking. And finally, to begin to think how they're actually going to evaluate it which is where I think the real challenge is. Is it good enough?

And what I would suggest is that if the overall

concept in the viability assessment is deemed viable by whatever means, whether that's Congress, the public, the NRC, somebody thinking to themselves, well this doesn't look like a bad start. Then at least you have, as with the design alternatives issue a base case to begin work from to at least see whether you're improving defense indepth by whatever criteria you're using to evaluate that, or whether you're moving away from it. And that's what's been lacking up to this point as I see it. And that's what makes it murky for me is it always implies a starting point to decide if -- somewhere you have to say, well, okay, that's the starting point I don't know if it's good, bad, or ugly, but at least now I can tell which direction I'm going in. And that's where I think the value is offered by the liability assessment in that context.

I'm still having difficulties in my own mind separating reduction and uncertainty in actually reducing the bottom line itself and how to weigh those two and their relative importance in looking at defense indepth. But this will force the staff to come to some decisions.

Said another way, if I had the answer I would probably become an NRC contractor. So -- or a DOE contractor.

CHAIRMAN GARRICK: Ray, you had a question or a comment?

DR. WYMER: George asked my question.

CHAIRMAN GARRICK: Charles?

DR. FAIRHURST: No.

CHAIRMAN GARRICK: Margaret, Mike?

MR. BELL: Actually, I have a question for the committee rather than the NEI visitors. I mean, having --

[Laughter.]

MR. BELL: Having heard my presentation on the staff's approach to reviewing to EA and now having heard the VA and having heard the NEI's views on the VA, do you see any disconnects between where the staff is heading and where these gentleman are suggesting we should be focused?

CHAIRMAN GARRICK: The simple answer is I don't. I think that we're thinking pretty much the same way. And I was encouraged by morning's session because I think we're beginning to really accept the concept of taking the performance assessment seriously as insight into prioritizing what we should be doing. And I'm encouraged very much by that and I think that's exactly what Ralph has been talking about and so, no, at least at the global level I don't see a problem.

DR. HORNBERGER: I guess the only thing that I would say, Mike, is that we might give some thought to the suggestion that perhaps 100 percent of the effort doesn't have to go into post-closure. That some thinking on

pre-closure issues would be very valuable. And I know you didn't say 100 percent.

CHAIRMAN GARRICK: I would agree with that.

DR. WYMER: I have the impression, Mike, that these folks are trying to squeeze a little bit more out of the liability assessment than maybe I got the impression that the NRC was that you're in the middle of the details of the liability assessment and they're thinking more grandly in how you might apply it on a broader front.

MR. FERTEL: As a tool from learning from in order to better define a licensing process going forward.

MR. KRAFT: And recognizing that others will apply it more broadly than even the authors or the primary reviewers will. And that's our point for one of the reasons why we make the point saying that you've got to recognize who are the audiences for the review. And, you know, Congress, the Administration, the TRB, all the other parties that have interests in this program will be looking at the NRC review as one of the primary reviewers.

And I would just repeat something Marvin said very early on is that there is a tendency, it's human nature that NRC and DOE staff have been interacting in a collegial manner for some time now and as in their interactions NRC staff says, well, you know, why don't you take this action and DOE says, fine, we'll do that. Okay. That's already

checked off. Why not this other action and DOE says, no, we don't think that's worth it. We've got reasons why that's not worth it. Okay. Well document that in the VA. And you review the VA and you tend to ignore what you've already agreed is done and focus on those. So out of 6,000 element, you know, 5,500 of them are fine, 500 are not, and the report is on the 500 that are not and leaves a very misleading impression to the public. And I don't think that would be done intentionally, I think that's just the nature of the process that needs to be guarded against because all the other parties that are reviewing

CHAIRMAN GARRICK: I think lest there's the wrong impression about these references to a collegial relationship we need to point out the technical change process and the interaction that has taken place has taken place in a very open environment.

MR. FERTEL: I think I said earlier it was very transparent and open and professional. I mean, I think it's been great. But I do think that that too will chance once the application is filed and you need to prepare for the change, not that it won't be professional and not that it won't be open, but it will be different.

CHAIRMAN GARRICK: Yes, I think so. Charles.

DR. FAIRHURST: Yeah, I would just like to elaborate on what George said about thinking carefully about

pre-closure issues. It goes a little bit to defense indepth. If one thinks it's going to take 30, 40 years to put this repository in and one might want to keep it open longer. It's a great opportunity during that time to demonstrate to the public and everybody the degree of understanding you have of this system and at what point you may or may not need to add a component which is an extra defense indepth for example, and I think there's a tremendous amount of learning that will be done and public acceptance or public understanding can be developed if it's done in an appropriate way. And probably NRC will have a significant role in that. So I too feel that this preclosure is not a negligible part of the whole exercise.

CHAIRMAN GARRICK: Right. I think that the concept of the operating period, a long operating period and even more so if there's an interim storage facility offers the opportunity to reduce some of the most significant uncertainties associated with the performance assessment such as, for example, the thermal load. If there's one thing we know how to measure it's thermal load. And with time and with the right kind of preclosure operating procedure there's nothing to prevent us from being very quantitative about what goes into the mountain from a thermal standpoint and even control that. So there need not be uncertainty there. But I think that if we don't think

about it at the preclosure stage, you know, we lose that opportunity as well.

The same could be said about inspection of the waste package and verification of the integrity of the waste packages to reduce the uncertainty associated with waste package failure. So I think there is a real important connection between the preclosure operations and the post-closure operations.

Another thing that's kind of interesting that I've said before is that we're talking about an operation here that's going to be longer than any reactor application before it's closed. And we wouldn't think of operating a nuclear facility for 100 years or 50 years, or much less 200 years without doing everything possible to assure ourselves that that operation is also extremely safe and we have measured everything we can measure to enhance our knowledge of the post-closure conditions.

So I think this committee is on record with thinking we ought to learn more about that.

DR. FAIRHURST: It contributes a great deal to the public perception and public understanding.

CHAIRMAN GARRICK: Right.

MS. FEDERLINE: Could I just clarify a bit? I think we're probably talking different things when we talk about preclosure. When we talk about preclosure we're

referring to those Part 20 and design requirements that really apply to the safe operation, ventilation, those kinds of things. There's another preclosure component which is for post-closure, it's monitoring of all of the relevant processes that go on that will provide you some insight as to whether the repository is behaving as it should behave.

And we're sort of splitting the two. John just reminded me, we are focusing on post-closure comments in the VA as those things that are going to be fatal flaws to the future safety of a repository. That includes any kind of thermal experiments that need to be done over, let's say, 10, 15 years, you know, from now. So we're not just focusing on what the 10,000-year issues are, we are focusing on that interim period that will give you confidence that the repository is performing.

The thing that we're not going to be commenting on, we're not going to be providing comments on costs, about engineering features, and we're not going to be providing comments on the adequacy of ventilation for some Part 20 requirement because we feel those have already been tested in the regulatory arena and that we can call on that as we move closer.

And just keep in mind, there is a structured review process. DOE is going to deliver a draft license application. We're going to use the same acceptance

criteria that we're developing in our issue resolution reports as a result of our performance assessment to review that draft license application. So we're going to have a couple of iterations of moving into licensing after the viability assessment.

In our view the viability assessment has a very special purpose. It's a management decision. And we want to provide input to that process rather than sort of focusing on the licensing issues.

MR. FERTEL: The only thing I would maybe add, Margaret, to what you're saying is that the issue closure reports are really important to the KTIs that you're dealing with, but we believe you've got a broader spectrum of requirements to license the repository and the project. And we'd want to make sure that you're looking at that broad perspective so that when volume, whatever it is that the VA lays out their licensing plan, if all they're dealing with is the resolution of the KTI issues, it's not going to be a complete licensing application to you all. And if all you do is comment on what they've done and not tell them that that's not complete, they will proceed down the road thinking it's complete because that's what they've laid out as their license application.

So, again, we'd encourage you and you may be saying this and I'm not understanding it, that when you

review the VA and it is a management decisionmaking document for them, but where you're going to help their management decisionmaking in all honesty is on that part of it that's laying out what they think is a licensing plan. So if their licensing plan is complete and you tell them that, that's great. If their licensing plan is incomplete and you help them understand what's necessary to make it complete, that's very important because then you're helping them implement their management plan for going forward.

CHAIRMAN GARRICK: Any other comments, questions, issues?

[No response.]

CHAIRMAN GARRICK: I think we've had a very good discussion, Marv, and I hope as we said at the outset that we have a chance to do it again sometime.

MR. FERTEL: Well, we're more than willing to do that. We appreciate the opportunity. You will see Ralph around here quite a bit, maybe even Steve. Feel free to grab them at any time, feel free to call me if you want more NEI involvement at any point. And we will plan on getting back with you for sure after the viability assessment comes out to follow up on more specifics.

CHAIRMAN GARRICK: Very good.

MR. FERTEL: Thank you.

CHAIRMAN GARRICK: Thank you very much.

All right. The committee now will move into the agenda item having to do with the preparation of reports. From this point on I don't think we need to keep a record.

[Whereupon, at 4:45 p.m., the meeting was recessed, to reconvene at 8:30 a.m., Thursday, April 23, 1998.]

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: 100TH ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW) MEETING

DOCKET NUMBER:

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.

Gerald Brooks

Official Reporter

Ann Riley & Associates, Ltd.



INTRODUCTION TO NRC SENSITIVITY STUDIES AND STATUS OF TPA ACTIVITIES

April 22, 1998
Presentation to the Advisory Committee on
Nuclear Waste

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Performance Assessment and HLW Integration Branch

OVERVIEW OF NRC'S INTEGRATED HLW PERFORMANCE ASSESSMENT ACTIVITIES

We Are Using Outputs from Ongoing Total-system Performance Assessment (TPA) Activities to:

- Support Regulatory Framework Development
  - Evaluate implementability of proposed EPA standard
  - Use knowledge gained in TPA activities, to develop risk-informed site-specific rule for Yucca Mountain
  - Use TPA to focus development of review plan

- Integrate and Evaluate Information Across Technical Disciplines
  - Evaluate issues and subissues in terms of total system performance
  - Understand the influence of uncertainties on compliance calculation

- Provide Feedback to DOE on System Performance
  - Independently evaluate DOE's TSPA-VA analyses
  - Determine the sufficiency of data necessary for license application

DEVELOP RISK-INFORMED SITE-SPECIFIC RULE

- Use TPA Activities to Simplify, Focus, and Explain Regulatory Criteria (e.g., replace unnecessary or generic siting and design criteria, SECY97-300);
- Ensure a Clear Relationship Between NRC Acceptance Criteria and the Compliance Calculation (e.g., TSPA Methodology IRSR); and
- Ensure that the Implementing Rule and Associated Review Plan are Consistent with Our Knowledge of the Yucca Mountain Site and Our Ability to Assess the Performance of the Site and Design (10 CFR Part 63/TSPA Methodology IRSR).

INTEGRATE AND EVALUATE INFORMATION ACROSS TECHNICAL DISCIPLINES

In Cooperation With Other Key Technical Issue Leads We Have and Will Continue to:

- Update NRC's TPA Code to be User Friendly, Workstation-based, Include New Repository Design Features, and Incorporate More Sophisticated Models When Appropriate (e.g., TPA 3.1.4 and TPA 3.2);
- Identify Key Elements for Subsystem Abstraction, (e.g., TSPA Methodology IRSR);
- Conduct Sensitivity Studies on Intermediate Outputs to Identify Model Improvements and Data Needs (Used in NRC/DOE TSPA Technical Exchanges);
- Conduct Sensitivity Studies at the Total System Level to Assess the Importance of and Confirm Resolution of Subissues (e.g., Provided Input into Budget Deliberations); and
- Document Results of these Activities in Issue Resolution Status Reports (IRSRs).

PROVIDE EARLY FEEDBACK TO DOE ON SYSTEM PERFORMANCE VIA REVIEWS OF TSPA-VA PLANS, TSPA-VA, AND DRAFT LICENSE APPLICATION

- Review TSPA-VA plans and Other Information to Evaluate TSPA-VA Approaches and Input Parameters;
  - TPA 3.1.3/4 Code has been Used to Provide Insight on Preliminary Approaches Expected to be in DOE's TSPA-VA Including:
    - ➞ Identification of Differing Approaches to Matrix Diffusion
    - ➞ Identification of Data Limitations (K_ds in alluvium; Np Solubility)
    - ➞ Identification of Differences in Treatment of Disruptive Events

- Use TPA 3.2 Code to Review and Independently Evaluate DOE's Results
  - Compare TSPA-VA Results With TPA Results
  - Probe parameters and Conceptual Models to Determine those Most Important to Performance

- Provide Feedback of the Independent Evaluations in IRSR's (e.g. TSPA Methodology IRSR) and Other Commenting Activities (e.g., Technical Exchanges).

STATUS OF TPA ACTIVITIES

TASK	STATUS	PROJECTED COMPLETION	COMMENT
1. TPA 3.1.3 Code (Migrating to 3.1.4)	In use	Completed	System-level sensitivity studies
2. KTI-level sensitivity studies	Complete	Documentation-08/28/98	Preliminary infor. discussed at TE and ACNW
3. System-level sensitivity studies	Near Completion	Documentation-08/28/98	Preliminary info. to be provided at TE and ACNW; Input provided to ongoing budget exercises
4. Completion of TPA 3.1 User's Manual	Undergoing Final QA Review	05/29/98	Draft provided to ACNW staff for training; Conceptual basis and parameters to be documented in Sensitivity Studies Report and made available to interested parties
5. TPA 3.2 Code	Being Conceptualized	07/17/98	To be used for TSPA-VA review
6. TPA 3.2 User's Manual	Evolution from 3.1 User's Manual	09/30/98	
7. TSPA Methodology IRSR	Final Draft complete	04/24/98	In Concurrence; includes insights (i.e., key elements of abstraction) from TPA activities

STATUS OF TPA ACTIVITIES

8. "Importance" Analysis conceptualization	Ongoing	04/30/98	Before TSPA-VA formal review
9. Update KTI IRSRs		7/98	Will include info. from Sensitivity studies and information received from DOE
10.Commission Paper on TSPA-VA Review		9/98 + 3 months	

TPA 3.1.4 APPROACH AND REFERENCE CASE

April 22, 1998
100th ACNW Meeting
Total System Sensitivity Analysis for Yucca Mountain

Tim McCartin
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Division of Waste Management
Performance Assessment and HLW Integration Branch

TPA 3.1.4 APPROACH

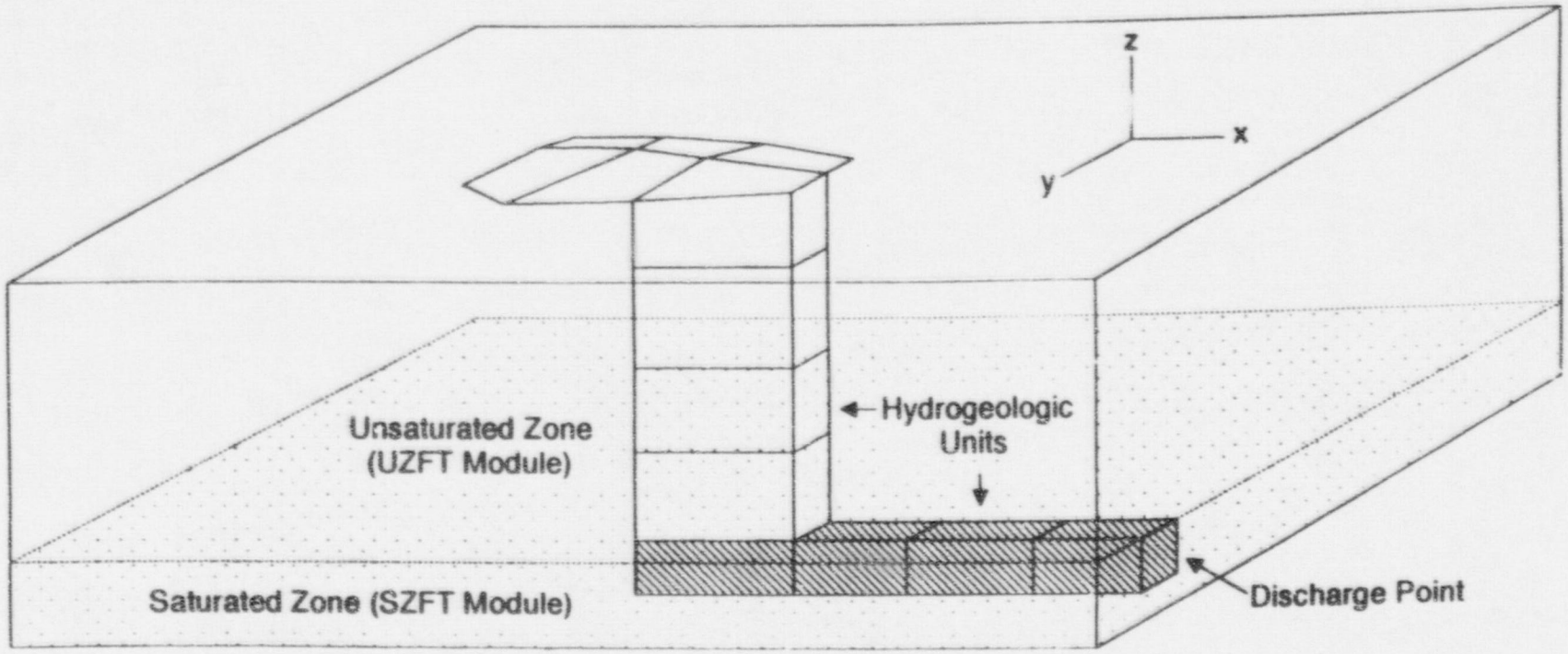
- **TPA 3.1.4, as part of NRC's Iterative Performance Assessment Program, was developed to provide insights on overall performance and assist reviews of DOE's TSPA**
  - provides a capability/tool with flexibility to consider a variety of concepts and models
  - use of conservative model or data range may be used, as appropriate, to limit the need for further development

- **Site information (including laboratory experiments and information from analogous environments) and results from detailed process models support PA abstractions**

NOTE: Use of a particular approach, model, or parameter in TPA 3.1.4 should NOT be construed as regulatory acceptance

CAUTION: INSIGHTS AND ASSERTIONS ARE PRELIMINARY
- PARAMETER AND MODEL DEVELOPMENT IS CONTINUING
- PRELIMINARY OUTPUTS BASED ON LIMITED ANALYSIS

Depiction of One-Dimensional Transport Paths
(Unsaturated and Saturated Zones)



PHYSICAL DESCRIPTION

- **Repository divided into 7 subareas (not limited to seven)**
  - variation in unsaturated zone stratigraphy
  - variation in deep percolation (assumes vertical flow)
  - variation in temperature and humidity

- **Representative waste package evaluated for each subarea**
  - degradation of waste package
  - release of radionuclides

- **Four saturated zone stream tubes**
  - two properties considered (fractured tuff, and alluvium)

TPA 3.1.4 Code Description

1) **Deep Percolation**
(How much water enters repository drifts?)

2) **Waste Package Degradation**
(When, what type, and how much water enters the WP?)

3) **Radionuclide Release**
(At what rate do radionuclides leave the EBS?)

4) **Unsaturated Zone Transport**
(At what rate do radionuclides enter the saturated zone?)

5) **Saturated Zone Transport**
(At what rate do radionuclides arrive at the receptor location?)

6) **Direct Release (volcanic event)**
(What amount of radionuclides are released by extrusive component to the receptor location)

7) **Dose Calculation**
(What is the dose at the receptor location?)

DEEP PERCOLATION

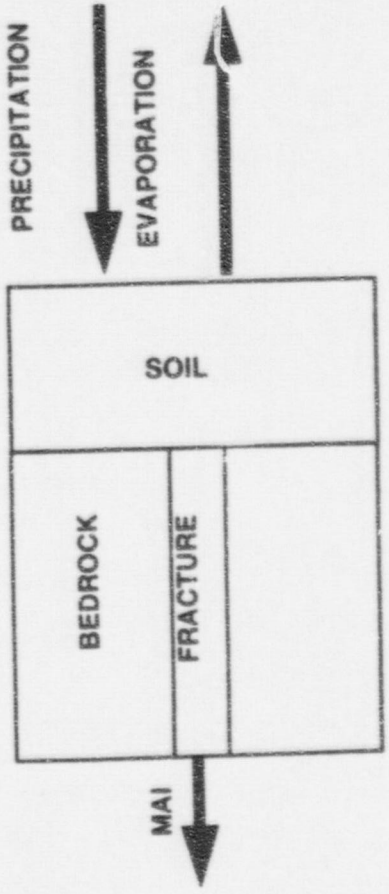
(How much water enters repository drifts?)

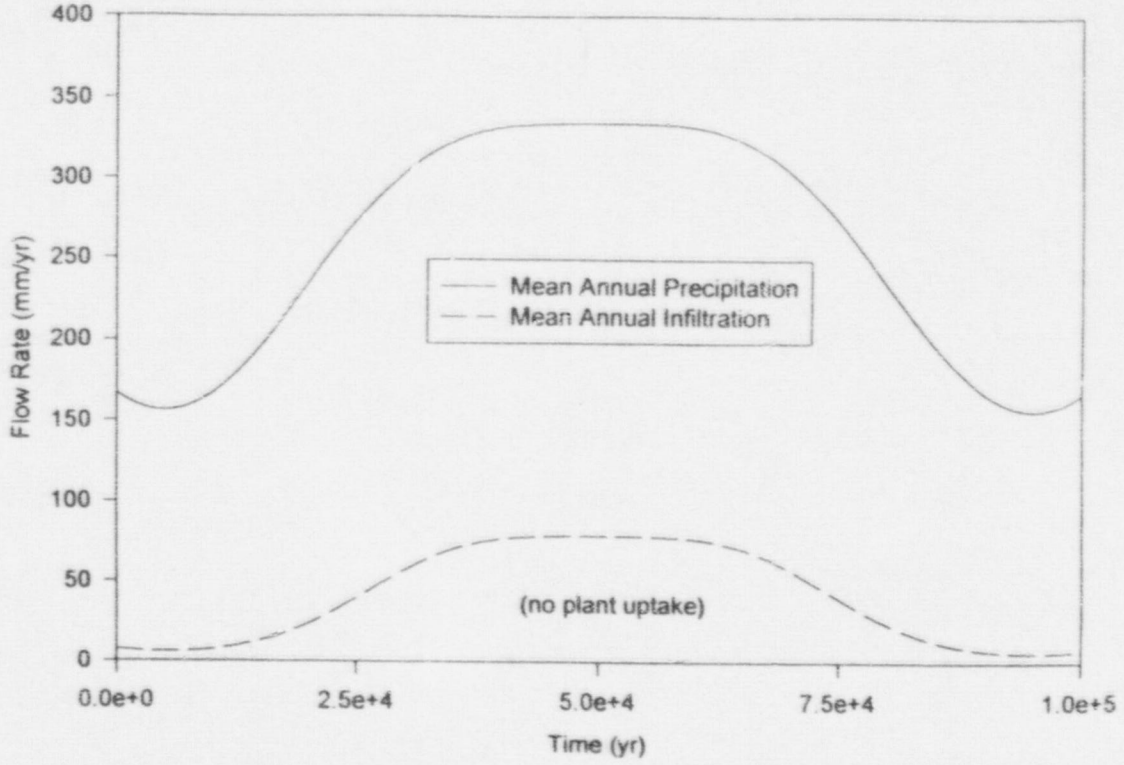
- **Temperature and Precipitation Control Infiltration Estimates**
  - Initial Infiltration, Uniform Distribution: [1,10] mm/yr
  - Precipitation Multiplier (at glacial max.), Uniform Dist.: [1.5,2.5]
  - Temperature Change (at glacial max.),Uniform Dist.: [-10,-5] °C
  - no consideration of run-off and transpiration

- **Reflux of Water**
  - refluxing water can be sufficient to penetrate the boiling isotherm (lifetime of container minmizes effect on performance when drips do not affect corrosion rate)

- **Amount of Water Incident on Drifts**
  - "Capture Area" (multiplies cross-sectional area of WP) Lognormal Distribution: [0.01, 3.0] (correlated)
  - Fraction of Area with Dripping Fractures Uniform Distribution: [0.0, 1.0] (correlated)

Approach to Estimating Mean Annual Infiltration





Waste Package Degradation

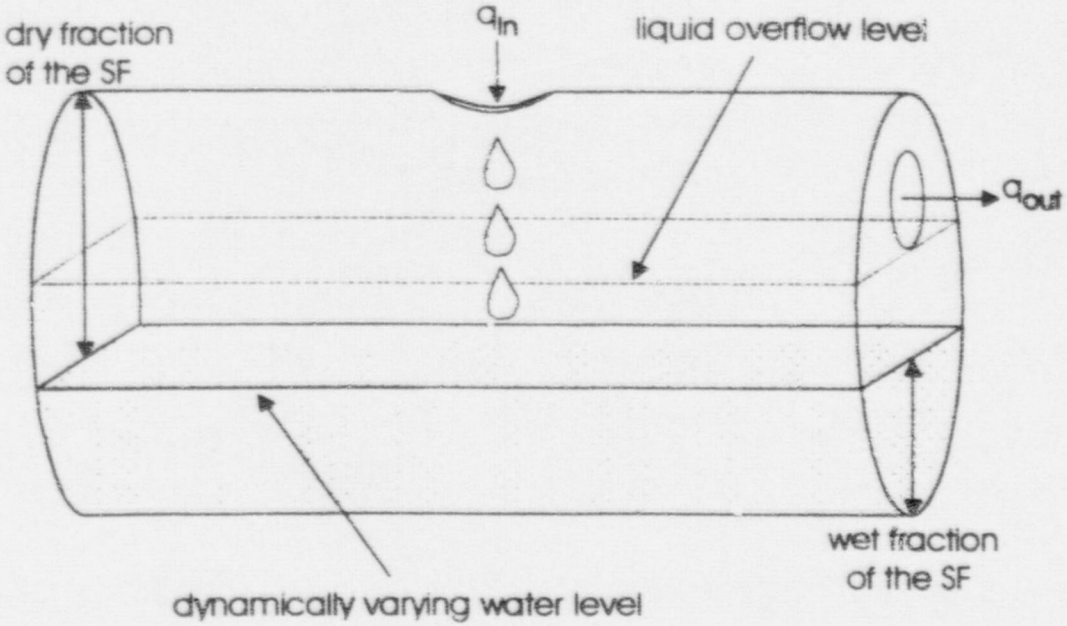
(When, what type, and how much water enters the WP)

- **Waste package corrosion**
  (temperature, humidity and water chemistry at surface of waste package)
  - representative container in a subarea used in determining corrosion of container
  - Critical relative humidity for aqueous corrosion; Normal Dist.: [75%, 85%]

- **Mechanical disruption of waste package**
  - fracture of the outer overpack due to thermal embrittlement
  - direct disruption due to faulting and igneous activity
  - rupture due to rock falls induced by seismicity

- **Initially Failed Packages**
  - Defective Fraction, Uniform Dist.: [1e-4, 1e-2]

- **Diversion of Water**
  - Fraction of Incident Flow Entering a Waste Package (diversion around and in drift and inability of water to enter pits); Lognormal Dist.: [0.01, 0.2]



Depiction of Bathtub Model

Radionuclide Release

(At what rate do radionuclides leave the EBS?)

- **Chemistry of water contacting waste form**
  - carbonate ion concentration and pH
- **Surface area of waste form contacted by water**
  - Bath tub conceptual model; Water Level, Uniform Distribution: [0.0, 1.0]
  - fragmented fuel pellets
  - options for cladding credit and flow-through model
- **Radionuclide release rates and solubility limits**
  - congruent dissolution of spent fuel with surface area calculation
- **Summation of releases over all failed waste packages**
  - time varying (different failure modes)
  - consideration of fraction that are "wet"

UNSATURATED ZONE TRANSPORT

(At what rate do radionuclides enter the saturated zone?)

- **Spatial and temporal distribution of flow**
  - long term climate change
  - seven subareas

- **Fracture versus matrix flow**
  - transport will be vertical from the repository to the water table
  - unit hydrologic properties and deep percolation used to determine fracture versus matrix flow

- **Retardation in fractures**
  (radionuclide retardation along transport paths from the repository to the water table)
  - matrix diffusion and sorption on fracture surfaces not considered significant
  - retardation in Calico Hills vitric unit significant (high matrix conductivity)

UNSATURATED ZONE HYDRAULIC PROPERTIES

(Lognormal Distributions for Conductivity)

Unit	K_m (mm/yr)	ϕ_m	β_m	K_f (mm/yr)	ϕ_f	β_f
Topopah Springs (welded)	[0.006, 0.6]	0.12	1.5	[2.5e+3, 2.5e+7]	[.001,.01]	3.0
Calico Hills (non-welded vitric)	[600.; 60,000.]	0.33	1.3	[2.5e+3, 2.5e+7]	[.001,.01]	3.0
Calico Hills (nonwelded zeolitic)	[0.1, 10.]	0.32	2.3	[1.9e+3, 1.9e+7]	[.001,.01]	3.0
Prow Pass (welded)	[0.3, 30.]	0.28	1.5	[1.9e+3, 1.9e+7]	[.001,.01]	3.0
Upper Crater Flat	[0.09, 9.]	0.28	1.4	[1.9e+3, 1.9e+7]	[.001,.01]	3.0
Bullfrog	[0.006, 0.6]	0.12	1.7	[9.4e+2, 9.4e+6]	[.001,.01]	3.0

UNSATURATED ZONE

STRATIGRAPHIC LAYERS AND THICKNESS (m)

Subarea	TSw	CHv	CHz	PP	UCFz	BF	Distance to WT
SA #1	33	---	163	34	67	---	297
SA #2	116	---	154	39	20	---	329
SA # 3	20	---	122	40	158	---	340
SA #4	110	---	132	34	57	---	333
SA #5	20	113	---	38	158	32	361
SA #6	53	125	---	26	136	---	340
SA #7	121	---	114	43	63	---	341

SATURATED ZONE TRANSPORT

(At what rate do radionuclides arrive at the receptor location?)

- **Four flow paths (repository footprint to receptor location)**
  - initially in fractured tuff (~13 km)
  - alluvium at receptor location
  - transverse dispersion neglected
- **Fractured Tuff**
  - transport only in fractures
  - matrix diffusion with retardation in the matrix
    (volume of matrix involved in matrix diffusion can be variable)
  - fracture velocities vary between 50 and 500 m/yr
- **Alluvium**
  - porous flow with retardation
  - alluvium velocities vary between 3 and 5 m/yr
  - Retardation Factors
    Np, Loguniform Distribution: [1.0, 320.]
    Tc, Loguniform Distribution: [1.0, 33.]
    Th, Loguniform Distribution: [1600., 32000.]

FAULTING

- Time of Faulting, Finite Exponential Dist.: [100; 10,000] years (recurrence probability: 10^{-5} per year)
- Fault length, Constant: [4000] meters
- Fault width (Northeast), Beta Dist.: [0.5, 275] meters; [1.25, 15]
- Fault width (Northwest), Beta Dist.: [0.5, 365] meters; [1.25, 15]

Seismicity (rockfall)

- **Recurrence rate**
  (0.1g - 500 yrs; 0.2g - 2400 yrs.; 0.3g - 8000 yrs.; and 0.4g - 20,000 yrs.)

- **Fraction of areal coverage for Rock Stability Types 1 thru 5**
  (type 1-3: 1.5%; type 4: 62.9%, type 5: 35.6%)

- **Rockfall volume:**
  - joint spacing (Type 4: 0.63 meters, Type 5: 0.36 meters)
  - rockfall column height -
    Type 4: 5.5m (0.1g); 6.5 m (0.2g); 7.5 m (0.3g); 8.5 m (0.4g)
    Type 5: 9.3 m (0.1g); 10 m (0.2g); 11.3 m (0.3g); 12.7 m (0.4g)

- **Rockfall distance, Constant: [2] meters**

- **Waste package ultimate strength**
  Normal Dist.: [1.31e9, 1.45e9] N/m^2

- **Heterogeneity Factor**
  Lognormal Dist.: [1.0e-5, 0.5]

DIRECT RELEASE

Volcanic Event (extrusive component)

(What amount of radionuclides are released by extrusive component to the receptor location)

- **Entrainment of spent fuel in ash**
  - number of containers intercepted by volcanic conduit
    Diameter of Volcanic Conduit, Uniform Dist.: [25, 78] meters
    (1 to 10 waste packages)
  - incorporation ratio of spent fuel into volcanic ash
  - spent fuel particle size

- **Air transport of ash**
  - deposition and particle size at receptor location
  - wind speed and direction
  - eruption energetics

- **Probability of volcanism**
  - Time of Igneous Event
    Finite Exponential Dist.: [100; 10,000] years
    (recurrence probability: 10^{-7} per year)

DOSE CALCULATION

(What is the dose at the receptor location?)

- **Dilution of radionuclides in groundwater**
  - pumping well characteristics and water use
  - Pumping Rate, Uniform Dist.: [4.5e6,1.3e7] gal/day

- **Dilution of radionuclides in soil**

  (direct release to surface from volcanism)
  - plowing and surficial processes
  - mass loading factor (air pathway)

- **Dose Conversion Factors**
  - lifestyle (time spent outdoors for direct and inhalation doses)
  - diet of locally grown food
  - representative person used to calculate dose
  - conservative approach for interception of plume
  - use of reference biosphere and cautious and reasonable assumptions

TPA 3.1.4 SUMMARY

- **TPA 3.1.4 is representative of current approaches BEING INVESTIGATED by NRC and CNWRA staff**
  - development is iterative
  - necessary flexibility to analyze a variety of approaches and concepts

- **Input Parameter Values and Distributions Based on NRC KTI Team Best Estimates, CNWRA Data and Auxiliary Analyses, and DOE Literature**
  - TPA.inp file about 2000 lines, Organized by Module and Documented with Comments

- **Full *tpa.inp* file, Conceptual Models, and Sensitivity Results (Documented late summer)**
  - Use of a particular approach, model, or parameter in TPA 3.1.4 should NOT be construed as regulatory acceptance

- **Initial Reference Case Calculations in S. Mohanty Presentation**
  Process Level Calculations in J. Firth Presentation
  Initial System Level Calculations in R. Codell Presentation
  - ALL results should be considered preliminary

COMPONENTS OF THE REFERENCE CASE

SCENARIO CLASSES

- Nominal Case
  - Undisturbed (present day conditions) + Climate Change (precipitation history) + Seismicity (affects of rockfall on WP failure)
- Nominal Case + Volcanism
- Nominal Case + Faulting

SYSTEM LEVEL SENSITIVITY ANALYSES (to date)

- Base Case
  - Undisturbed (present day conditions) + Climate Change (precipitation history)
  - Alternative Conceptual Models

PROCESS LEVEL SENSITIVITY ANALYSES

- Focussed on evaluation of individual modules or processes