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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON NUCLEAR WASTE

(ACNW)

137TH MEETING

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WEDNESDAY

SEPTEMBER 25, 2002

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LAS VEGAS, NEVADA

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The Committee was called to order at the Texas Station Hotel, Amaryllis Room, 2101 Texas Star Lane, North Las Vegas, Nevada 89109, at 8:30 a.m., by Dr. George Hornberger, Chairman, presiding.

COMMITTEE MEMBERS PRESENT:

DR. GEORGE HORNBERGER, Chairman

DR. RAYMOND WYMER, Vice Chairman

DR. B. JOHN GARRICK, Member

MR. MILTON LEVENSON, Member

DR. MICHAEL RYAN, Member

DR. JOHN LARKINS, Executive Director

DR. SHER BAHADUR, Associate Executive Director

ALSO PRESENT:

ACNW STAFF

DR. ANDY CAMPBELL, NRC

JEFF CIOCCO, NRC

PAT MACKIN, NRC

BUDHI SAGAR, NRC

TIM MCCARTIN, NRC

I-N-D-E-X

P-R-O-C-E-E-D-I-N-G-S

(8:43 a.m.)

CHAIRMAN HORNBERGER: The meeting will come to order. This is the first day of the 137th meeting of the Advisory Committee on Nuclear Waste. My name is George Hornberger, Chairman of the ACNW.

The other members of the committee present are Raymond Wymer, and we don't have name tags. Raymond is sitting two seats to my left. Raymond is the Vice Chair of the ACNW.

John Garrick is sitting to my left, and Milt Levenson is sitting to my right, and Michael Ryan is sitting two to my right. Before discussing the topics for today's meeting the committee would like to express its thanks to members of the public that attended its meeting this past Monday night at the Bob Rudd Community Center at Pahrump.

It was an interesting session, where we exchanged thoughts for several hours, and updated the committee's understanding of current relevant issues as viewed by local citizens.

Also, the ACNW had a field trip to Yucca Mountain and to the Area 5 Waste Management Site yesterday, and we would like to express our thanks, our particular thanks, to Carol Hanlon for organizing the trip.

During today's meeting the Committee will receive an information briefing on the status of DOE and NRC issue resolutions; two, receive a status briefing on the forthcoming NEUREG 1762, which is the Integrated Issue Resolution Status Report; receive a briefing on public comments received on the Yucca Mountain Review Plan, which is NEUREG 1804; and receive an information briefing on the analysis of well drilling activities in the Amargosa Desert area.

And then a schedule change; this afternoon, instead of tomorrow afternoon, this afternoon the DOE will present its presentations on Chlorine-36 and microbial-induced corrosion studies.

We will also reserve time for interactions with stakeholders and meeting participants. John Larkins is the Designated Federal Official for today's initial session.

John Larkins is here on the right, and he is the Executive Director of the ACNW, and on the far right of the table is Sher Bahadur, who is the Associate Executive Director.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. We have received no requests for time to make oral statements from members of the public regarding today's sessions.

Should anyone wish to address the committee, please make your wishes known to one of the committee staff. It is requested that the speakers use one of the microphones, identify themselves, and speak with sufficient clarity and volume so that they can be readily heard.

All right. So we are going to, after having computer problems resolved, and we are starting a little late, but I think now we are ready to go, and our first presentation has to do with the status of the KTI Issue Resolution. And I am not sure who is going to do this.

Oh, we have a switch. Another switch. Okay. So, Mike, are you going to go first?

MR. ANDERSON: I am.

CHAIRMAN HORNBERGER: I don't know. Is that what is happening? No, we just had a glitch. Jim Anderson is actually going to do the KTI presentation, but he is not going to talk on the history of water use. So I think in a minute we will have the next glitch finished and fixed.

(Brief Pause.)

MR. ANDERSEN: (Off microphone) I am Jim

Andersen, and I am one of the project managers in the Nuclear Waste Management for the NRC. The objective of this first briefing is to have an overview of key technical issues and the process of the status.

Part of this status will be providing the committee with two more presentations after this with the status of the forthcoming NUREG-1762 which was mentioned earlier; and then the third briefing will focus on the NRC staff analysis on the Yucca Mountain Review Plan.

(Brief Pause.)

MR. ANDERSEN: The outline for this presentation is that I am going to focus on three main areas. One, the overall status of the key technical issue agreements, and second, I will focus on Fiscal Year '02 activities, three specific ones; the DOE KTI planning strategy in a meeting that we held both in April and July of this year.

The second is the NRC risk insights initiative, and the Committee has already receives some briefing on that already, and I am going to highlight more of the aspects of how it impacts issue resolution.

Thirdly, I am going to briefly touch it in this presentation, but I will cover more in-depth in the next presentation, and that is the integrated resolution status report.

The third area that I want to discuss is some of the Fiscal Year '03 to '05 issue resolution activities that DOE presented as a preliminary plan in July of this year on their planning for '03 to '05.

Some of the NRC staff concerns which we discussed at that meeting, and then some general path forward items for the next couple of fiscal years. Next slide.

Before I get into the status of the key technical agreements, I would like to give some very quick background information. Back in August of 2000, we started a series of meetings with the Department of Energy to discuss nine of the key technical issues. There is 10 in total, and the remaining one has to do with EPA's rules.

But the meetings that we had with DOE just focused on the nine key technical issues. The first four backup slides list all of the key technical issues, and a one to two sentence description of the key technical issues.

The backup slides also discuss the status and the terms that we were used for both pending and open, and for the key technical issue sub-issues, and the status of all of those subissues, if you are interested in that information.

During the meetings with the DOE, we discussed the underlying key technical issues and subissues, as well as questions which are documented in the individual key technical issue resolution status reports.

And based on those discussions, the DOE and NRC reached agreements on what information the NRC staff would need to conduct a potential license review.

From the period of August of 2000 until September 2001, we conducted 17 key technical issue public meetings, and also one preclosure meeting during that period.

As a result of those meetings, 293 agreements were reached, which I will provide the status of in the next slide here. Since September of 2001, we have had additional meetings with DOE to discuss the status of the agreements, the path forward, and those meetings have not resulted in any further agreements.

Additional agreements are planned for Fiscal Year '03, and we have had one preclosure meeting on Fiscal Year '02, and that's why I had two listed on this slide, the previous slide.

The additional meetings that we plan to have in Fiscal Year '03 hopefully will address some of the key technical issues in more detail with DOE, who is ready to discuss how they plan to address those key technical issue agreements.

And in addition we will have preclosure meetings since the first one only highlighted part of the whole preclosure topic. Additional meetings could result in further agreements. You are actually one ahead of me, and so if you could stay there.

With that, I will now give you the status of where we are, and I have it as of last week. For the last few years the DOE has provided information on the agreements, and as of the 18^{th}, the NRC has completed the review of 61 of those, and has determined that 61 have been complete.

And complete during this prelicensing period means that the staff has no further questions at this time, and not that a licensing decision has been made, and that is important to note.

Of the remaining 232 agreements, 33 are currently under NRC staff review, and 199 have not been fully addressed by the DOE. By fully addressed there, it doesn't mean that the DOE has not provided information on some of those.

Some agreements require maybe two different submittals, or probably two topics where DOE said they are going to provide two different documents to address the total agreement.

So they may have provided half of the information already, and which they are waiting for the other half. Also included in that category is agreements where DOE provided the information and the NRC staff had additional questions that they wanted DOE to address.

So I just wanted to make sure that there was an understanding that the DOE has not addressed 199 total. It is a less than that number. Next slide, please.

Moving into the Fiscal Year '02 issue resolution activities, like I mentioned earlier, I wanted to stress three specific areas that DOE is scheduling a binning of the agreements, and the risk insight review, and the integrated issue resolution status report. Next slide.

Regarding the scheduling and binning of agreements, in April of this year, the NRC and DOE had a public technical exchange meeting to discuss key technical issues. During that meeting the DOE provided an overview on how they planned to evaluate the total work scope to get them for Fiscal Year '02 to a potential license application, including DOE's plans to address the key technical issue agreements.

As part of that meeting the DOE discussed now to bin the agreements into four groups, and I will discuss the binning shortly. DOE also provided the staff with those agreements and plan to address them in the remainder of Fiscal Year '02.

And at that point in April, they had not completed the planning for Fiscal Year '03 and beyond. Next slide, please.

The agreements were not completed as of April of 2002, and DOE binned them into four groups. In Bin-1, DOE stated that they would provide analyses or data that would address the liberal scope of the agreement.

The only thing that would change would possibly be the date that we set for the technical exchange.

Bin-2 was a revised scope, and DOE stated that even though the scope of the information provided would be different from the original agreement, it would meet the intent of the agreement.

A lot of Bin-2's, or at least the ones

that we have seen so far, the major change has been that DOE was provided with different documents. The agreement might call for them to address the agreement in a specific AMR, and DOE addressed it in a letter report or something like that. There has not been a significant change.

In Bin-3, DOE stated that they would provide additional analysis and documentation that included risk information as an alternative basis for closure of the agreement.

DOE stated that generally the risk information will demonstrate the subject of the original agreement did not contribute significantly to the overall system performance.

And then Bin-4, the last area, the DOE stated their basis for the resolution as a result of a change of circumstances. For example, a change in design of the original, and that the agreement is no longer applicable.

At the meeting the NRC noted two things that I would like to just mention here. The NRC staff stated that we would not be reviewing or formally reviewing or endorsing DOE's plan to get them to a potential license application.

The second thing is that we would not be challenging the binning of the agreement. We were more interested in how DOE was planning to address the information and would be more interested in the actual letters to address the agreement, and not the actual bin number that they put it in.

And as I said in the beginning, if you have any questions, please stop me. I just wanted to give you a feel of the results from that April meeting. During that meeting DOE discussed 61 agreements, which they said at the time they were looking to address for Fiscal Year '02.

And it laid out a schedule for those agreements. The 61, most of them have been delivered on time, and the status of the 61 I list there. Thirty are currently under review, and 13 have been listed as complete, and 40 for additional information, which we have sent to the DOE.

Nine remain to be submitted, and five others, the other category I think, that during that actual April meeting the DOE noted that three would be pushed into Fiscal Year '03, and I believe the other two were -- that DOE has only partly provided the information.

So the intent of that slide was just to give you a feel for how DOE did on those specific ones that we discussed during April. Moving on to the second item for physical year '02 was the NRC risk insights initiative.

Last April, I believe, the committee was briefed on the NRC risk insights initiative, and I think the Committee has since written a letter on that information, and I think that the staff has responded to that.

Therefore, I am not going to go into too much depth in this area, but I wanted to highlight how this initiative will impact and contribute to the issue resolution process.

First, let me just go back and go over the objectives of the initiative. First, to document the existing risk information, and tie the information to KTI issue resolutions.

Enhanced resolution of the risk information, both internally and externally. Third, to incorporate risk information to the agreement issue resolution process; and lastly to identify additional risk information necessary to support the issue resolution process.

During the April meeting with the committee the staff discussed the preliminary results of this initiative, and there is still preliminaries that we have not formally documented as of yet.

I think one of the main points which definitely I understood when we made the agreement with you was that the agreements are definitely not all alike. Some required that DOE provide a database of information, and some required documentation of the task, and other agreements required DOE to do a moderate amount of research or effort to address the agreement.

So as the NRC staff went through its initiative here, we came up with 41 agreements where we listed them as being of high or medium high importance. And a backup slide, the last backup slide, has the specific KTI agreement numbered where these fall into a kind of a description of where they fall.

But the three main areas, if I could summarize, are the degradation of the waste package, and the chemical environment of the waste package area, and also previous activity. And then if I added a fourth, it would probably be uncertainty and carrying uncertainty in the TSBA, and it falls within that agreement. Next slide, please.

Now, what are we doing with the information and how that impacts and contributes to issue resolution. First, the staff has documented the existing risk information, and documentation will include references to available analyses which support our basis for issuing of resolutions, as well as the plain language description of our understanding of the system.

The second is that the staff is currently using the preliminary results during the issue of the resolution activities and to focus on those issues deemed most important.

And lastly the staff plans to repeat this process to enhance the understanding of the risk significance of the issue. The next phase of this will include more focus criteria than we had this first time.

As part of these three activities the staff is performing analyses to help further understand the risk information, and Tim McCartin, like I mentioned earlier, will discuss those analyses further during the presentation.

The third area in Fiscal Year '02 is the integrated issue resolution status report, NEUREG 1762. This is the subject of the next presentation and so I am not going to go into too much depth at this point. But it was issued in July of 2002, and provides a status report on the issue resolution process.

It documents technical basis and the NRC intent of the agreements, and should be used as an aid in understanding the background of the agreements, and conditions from the key technical issues of the draft of the Yucca Mountain Review Plan framework. Next slide, please.

I would like to move a little bit forward into Fiscal Year '03-'05 issue resolution activities. Like I mentioned earlier, I plan to discuss DOE's preliminary plan.

The DOE had provided us the final plan, and Tim Gunter brought me this this morning. But this briefing discusses the preliminary plan. I don't think there is any major, major changes. Some of the numbers might change in the next couple of slides.

But anyway I will discuss the preliminary plan we discussed in July, and the DOE binning of the remaining agreements for Fiscal Year '03 to '05. And some of the NRC staff concerns that you discussed at the July meeting, and some path forward issues. Next slide.

During the July 2002 technical exchange, DOE presented again an overview of the process of scheduling and binning of the two technical issue agreements. At the meeting the DOE presented a preliminary schedule for the remaining agreements. It is important to note that DOE's preliminary list did not include the agreements where the NRC has asked for additional information, or it did not include some of the agreements that had been partly responded to by DOE.

Therefore, if you add up these numbers, I think they come up to 165, but it does not equal the 199 that I discussed earlier. So if you are just doing a check on me, that's the reason why the numbers don't add up. Next slide, please.

During the July 2002 meeting the NRC noted a couple of concerns with the DOE plan. First, and it is not listed on the slide, was the overall schedule. Most of the agreements are going to be addressed by DOE during the period of July 2003 to roughly March of 2004.

The staff understands the test schedules and overall project planning, and the impact of the schedule, but where possible the staff noted that if it would be more of a flatter distribution that it would help the staff in scheduling work, instead of more of a Bell curve, which is currently the case.

And although we understand as I mentioned the scheduling and tests do dictate the scheduling. In looking at the 41 agreements that I mentioned earlier that came out on the top high or medium-high in the NRC risks insight initiative, we noted a couple of things.

One was that some of them were classified material in Bin 3, Bin 3 meaning that the DOE was going to provide risk information to show that it was not a significant or repository performance. So we just noted at that point that we did not discuss the agreements specifically, but we definitely agreed with DOE that we needed to have further discussions on those specific agreements, because there seemed to be a slight disconnect, at least on the initial ones.

Secondly, some of the 41 agreements we noted as high or medium-high, and were toward the end of the DOE time schedules, and some as late as October of 2004. I think the DOE made an effort to try and push some of those up in the final plan.

Again, I have not seen the final plan and so I think that some of those might have moved forward in the schedule a little bit. But for those agreements late in the process, we definitely want to have some discussions with DOE early and understand their approach as much as possible, rather than getting the information very late in the game.

Lastly, the NRC staff was concerned with agreements related to uncertainty, which was listed as Bin-3's. It was not clear to the NRC staff how risk information could be used to address uncertainty and again we just noted at that point to the DOE and the NRC that we needed to have additional discussions to understand how risk information could be used to deal with those specific agreements. Next slide.

Let me head into Fiscal Year '03, and the DOE is planning to submit or has submitted I should say now its final plan for '03 to '05. We plan to have some telephone calls initially to discuss that plan, and hopefully we will have further public interactions to discuss that plan in more depth.

We also plan to discuss generically how Bin-3 items, or what information DOE and the NRC would need for the Bin-3 items. The DOE had just provided I guess in the last week or two some Bin-3, or which have been classified as Bin-3 agreements with the risk information.

And we have done some reviews of those and we have some generic concerns at this point that we need to discuss with the DOE to make sure that in the future that the information that they provide for the Bin-3 agreements, that we both just have a common understanding of what we need to say that the items are complete.

And lastly I think in participation that we need to have additional meetings, and definitely in the pre-closure area, where we have not addressed all the different safety topics in the pre-closure area.

Also the key technical issue agreements, we have some planned already, and we have increased activity plan which has been accepted for later this month. And also a tentative COST meeting planned for October.

So we need to continue to have discussions and understand DOE's approaches to these agreements. So I believe that there will be a number of future meetings in Fiscal Year '03.

In summary, I believe that the issue resolution process is progressing, and the NRC staff is actively monitoring the agreements. The NRC and DOE need to continue discussions on the agreements. I think that is the key area so that both the NRC intent of the agreement and how DOE plans to address the agreement are discussed.

And then the staff will continue to refine the use of risk information during these later issue resolution meetings. And that is the presentation I have, and the backup slides again have the key technical issue definitions, and the status of the agreements, and the status of the KTI subissues, and a little bit of information on the risk initiative results of those 41 agreements.

At this point, I would ask if anyone has any questions.

CHAIRMAN HORNBERGER: Thank you. Jim, on your Slide 15, where you were talking about your '03 to '05 activities, the second bullet says some of the 41 agreements were listed as Bin-3 by DOE. Can you give me a feel for how many some is? An order of magnitude; is it 20?

MR. ANDERSEN: No, it is not 20. It is probably -- I would say it was eight or somewhere in that area.

CHAIRMAN HORNBERGER: And along the same lines, you point out that some of the agreements listed as Bin-3 by DOE relate to uncertainty issues, and that the NRC staff was not sure that this was appropriate. Can you enlighten me on what that means?

MR. ANDERSEN: Yes. Some of the agreements requested, or asked, or were concerned with how DOE was dealing with uncertainty in certain parameter values, and things like that, and as for any further clarification, if any of the staff had further examples, maybe that would help.

But DOE listed Bin-3 and saying that we were going to use risk information to address it. So there was some disconnect there on how that would work, at least from the NRC staff's point.

CHAIRMAN HORNBERGER: I guess I was just trying to -- well, the NRC staff doesn't separate issues of uncertainty from risk.

MR. ANDERSEN: No.

CHAIRMAN HORNBERGER: Raymond.

VICE CHAIRMAN WYMER: You used the term risk information in a lot of different contexts in the presentation, and I think we all sort of have a fuzzy understanding of what you mean by it, but I suspect that a number of people in the audience really don't have a firm grasp on it.

And so could you give an example or two so that you could put it in a little bit more concrete terms as to what is risk information?

MR. ANDERSEN: Well, maybe Tim -- Tim, do you have any examples, or are you going to go into that in your presentation at all?

MR. MCCARTIN: Yes. Well, I will be addressing that in my presentation. Tim McCartin, NRC staff. Risk information, as we would look at it, it would be quantitative information, in terms of the performance of the repository, and what aspects of the repository system affect the quantitative numbers the most.

VICE CHAIRMAN WYNER: Will that do the job?

CHAIRMAN HORNBERGER: Thanks, Tim.

DR. GARRICK: I just wanted to pick up on that thought for just as second. In the risk initiative, the first bullet said to document existing risk information and tie the information to KTI resolution, and somewhat in the same vain as Ray's comment for the public, I think it is important to note there that the connection here is substantive, and it is not the KTIs that are necessarily the focal point from a point of view of risk.

Because we have always questioned the risk basis of the key technical issues, and what is the perspective here is the risk modeling and the risk analysis, and what it says, if you wish, relative to the ranking and importance of the different KTIs.

And there is a great deal of information on that, of course, and the briefing looked and went into an honest detail about that, but I just wanted to make the point that the KTIs, while they have been the bulwark of the NRC's perspective on what had to be resolved, they are not the product of a list assessment.

And the important point there is that we need to more clearly understand, and the public needs to more clearly understand the KTIs in relationship to the experts are telling us as to what the real risks are, and so that is just a comment.

MR. LEVENSON: Jim, I have a two-part question that sort of asks you to guess or make an estimate, and so bear with me. The whole KTI program was based on a preliminary design, and the design has been evolving, and in fact I don't think we are privy to what will be the final design.

We won't know that until we see the LA. Would you care to make an estimate on how many of the KTI agreements will no longer be valid and be abandoned because they are relevant to some aspect of the design that is no longer there?

And the other part of the question is how many new agreements or questions might arise from what become new design elements that you have not seen up until now?

MR. ANDERSEN: Sure. The current agreements, I don't know of any instance where any of the agreements become null and void at this point. DOE has said there are a few and that they plan to come in and tell us which ones those are.

I don't know of any at this point, and I don't think we have seen any formal DOE changes in design from what we discussed mostly at the meetings. So at this point I don't know of any that are LA. Moving forward, if DOE does make changes, and for instance, a pocket forward repository issue, we had a meeting back I guess almost a year ago where we discussed hot versus cold repository.

And during that meeting we discussed a number of issues, and I think we binned a lot of issues, and I would on the issue of 30 or 40 issues that we had, and said that if DOE decided to go to a cold repository, these would be things that we wanted to address.

So if they decided to go to a cold repository, I think we would go back and look at that list, and I think many of those would result in new agreements with DOE. Other areas, you know, if they went to a much larger footprint, which I have seen a bunch of different designs of the repository, that could add additional agreements, depending on how it was characterized.

And so there are a number of design changes which I know that are being talked about that could lead to further agreements, but at this point, the DOE has not told us formally that they are going that way. So the agreements are where they are.

MR. LEVENSON: Well, I just wanted to make the point that this set of agreements is not a rigid thing because it was for a design which may or may not be what is in the LA.

MR. ANDERSEN: Right. The agreements were just basically a vehicle that we used to have discussions with DOE on what issues are out there. If DOE changed the approach, a hundred of the agreements could go away, and we could add 150 more. And I am just throwing out numbers, but it was a vehicle that we could use for discussions with DOE and a way to track issues.

CHAIRMAN HORNBERGER: Thanks, Jim, and I have another follow-up question here. As I look at your last slide, and where the staff chose those 41 that were of special importance, and I guess I could pick any of these I suppose, but as I look in the upper right-hand quadrant, you have unsaturated and saturated zone flow under isothermal conditions, and you are looking at model support for seepage, alcove and niche tests.

And that is marked as a complex large effort. My question is when we look at these complex large efforts, we have a sense that the data, or the timing of the data made available from these complex large efforts, aren't these such that if the DOE is to go forward with the license application in that time frame that they are looking at, they are going to have to have a cut-off point where they will --for the data, as input into the license application, because as we know that in itself is a pretty complex undertaking.

So my question is that when you look at these 41, what degree of confidence does the NRC staff have that these -- that all of these are going to be addressed satisfactorily by the time of license application, and if they are not, can you give me a feel for how much of this you see as necessary for a license application, and how much of it you could see extending into a performance confirmation curve.

MR. ANDERSEN: We did a very quick look -- and I believe it was at the end of last year -- at all of the agreements, and part of the numbers, or part of the moderate effort or large effort that groupings here came out of that review, but we looked at all of the agreements and tried to get an estimate of how many FTE it would take DOE to do it, and that is a pretty rough guess.

But after that review, we came to the conclusion that we didn't know of any agreements where they could not provide us enough information by the time of license application. Now, that doesn't mean that they will nor not, but that was our conclusion at the end of that review.

So, of course, a lot of that information, DOE will continue to do testing, and a lot of that will fall into the conformance confirmation period, or the receive and possess application.

But we believe the information that is necessary for the construction authorization can be obtained by their current due date. And as far as the -- and I don't know all the agreements by heart, but the one that you mentioned -- the one that you mentioned about the unsaturated zone 401 agreement, the reason that is listed as large effort or medium-large, or however it is listed there, is a kind of a -- well, it asks for the test results and test plans for 7 or 8 tests that hydrological tests that the DOE is doing.

And so it is a very cumbersome agreement, and so that's why it came up with a large effort.

CHAIRMAN HORNBERGER: Questions from the staff? Anyone? Does anyone else have any questions or comments? Judy.

MS. TREICHEL: Judy Treichel, Nevada Nuclear Waste Task Force. Has the terminology changed on your Slide 8 when you are talking about the 61 agreements and 30 other reviewed and 13 complete, do those still fit into the category of closed and closed pending, and how are they listed; or how that terminology changed now that you are into the YMRP stage?

MR. ANDERSEN: Now, Judy, I have to go into a little bit more detail. Okay. KTIs. There are nine key technical issues, and there is 37 key technical issues subissues. The subissues we list as closed, closed-pending, and open, like we have throughout the process.

The actual agreements, I don't use those as significant classifications. If you look on the slides, one of the backup slides, Slide 23, for the actual agreements, we used five classifications or whatever, and not received meaning if DOE has not provided any information pertaining to the agreement, and partly received where DOE has provided some of the information, but not all of the information from the agreement.

Received means that DOE has provided all of the information pertaining to the agreement that is currently under staff review. Complete means that the staff has reviewed the information that DOE provided, and has not further questions at this point.

And the last category is any additional information where we have reviewed all of the information that DOE has provided for the agreement, and we still have further questions.

So there is a distinction between the KTI subissues and the actual agreements and how we classify the agreements, versus the subissues. Did I answer your question? It gets kind of confusing I realize.

MR. KESSLER: John Kessler, EPRI. I guess it would be wise or appropriate to say that the KTI agreements as they were originally filed, came out of the 17 or so meetings that happened. A lot of it was, oh, gee, it would be nice if you showed me this.

And, yes, we will show it to you and the risk insights weren't part of that whole process of originally coming up with these 293 agreements. A lot has happened since then, as you are all aware.

And if I assume that the NRC themselves feel that 41 of these are high to medium high, and let's assume that those 41 are separate from the 61 that have already been concluded, we have got 180 that the staff feel fall below even the medium importance.

I think that is probably close to what DOE feels as a whole, and below importance as well. I guess what I would request is that the committee take a look at those 180, and maybe not one by one, but sort of the process by which these 180 fell through, and perhaps suggest to the staff that the staff initiate a closure on those 180 or so agreements, rather than waiting for DOE to do it.

That would certainly help clear the books, and focus on what now seems to be a general agreement, except for these eight or so, and whether there needs to be more discussion and proceed.

The other thing that wasn't considered at the time that the agreements were put together was when is this information needed. It sounds like most of the information that is felt is really needed ahead of the construction application. I think since then that both the DOE and NRC have revolved their thinking about what is performance confirmation, and what is needed before a construction application.

And I would suggest that the committee take a look at that, and perhaps review those remaining 41 or however many agreements it turns out to be at the end.

And look to see whether all of that needs to be done ahead of time, and what level of information is necessary for a construction application, and where obviously the intent of performance confirmation is to increase confidence as one increases the risk of proceeding.

MR. ANDERSEN: And if I could comment on that just a little. Going to the first part of that, the risk information used. I would agree with you that a lot of the agreements, or all of the agreements were made a year or two ago, and a lot has changed since then.

That was one of the reasons that the NRC started looking at the risk information, and one of the reasons that the DOE is looking at it as well, and finding that some of the agreements may not, based on changes or whatever, meet the threshold of an agreement, per se.

We are looking at that, and DOE is looking at that, and we would not be adverse to deleting agreements if that were the key, and DOE felt that it was important and we felt that it was important>

We put most of the burden on DOE to start that process, although we are looking at it as well. The second half of that first question, although not all of the agreements go after the risk. The risk can't be used for all of the agreements.

And I say that because there is a requirement in Part 63 about multiple barriers. Some of the agreements go after information to discuss the capability of a barrier. And since we at the NRC staff at this point don't know which barriers the DOE is planning to use in their license application, we asked for information on all the barriers during those meetings.

So if the DOE came to us and said we are not going to take credit for X in the license application, that could lead to us saying, okay, we don't need these specific agreements.

But at this point it is not clear to us what barriers the DOE is going to take credit for. So that is why some of the agreements are still -- they be of low significance, but we still have them in there because they may be used to define variable capability.

The second half of the schedule of the comment, I would agree with you that not all of the information needs to be submitted for a construction authorization, and some could be in performance confirmation, and it is up to the DOE to provide us enough information where we can make a construction authorization, and that's why I think we need additional discussions with DOE on the agreements to try to get to that point. So those are my comments.

CHAIRMAN HORNBERGER: Steve.

MR. FRISCHMAN: Steve Frischman, State of Nevada. I can't let John's recommendation to you go by without being noticed. I think that you will see on the comments on the Yucca Mountain Review Plan that there is some really fundamental issues that have been raised, primarily by the thrust of comments, the State of Nevada, versus the comments from the Department of Energy.

And I would think that it would be probably even counterproductive to start looking at having the NRC staff start sorting out the agreements without knowing what a final Yucca Mountain Review Plan is going to look like, because what all of this is leading to is a license application and the staff's review of that application.

These agreements are what the staff and DOE agreed is on work that is necessary leading up to that, and there were agreements that were in the absence of a review plan.

So I think it would be premature and as I said counterproductive to have the staff have the burden of sorting through these agreements and thinking about what may be necessary and what may not be necessary before they know what their own review plan really looks like.

And you will see, if not today, in the very near future, you will see that the thrust of DOE's comments on the Yucca Mountain Review Plan is a debatable thrust. What they are doing -- and we have analyzed it pretty well, or pretty carefully, and we in fact are providing a written review of their comments to the staff and also to the Chairman.

And you will see that among other things what the Department did in its comments was try to recapture some of the comments that they made about Part 63 that were not agreed to by the Commission. They were not incorporated in 63.

They are trying to change the fundamental framework of licensing. So I think these agreements need to sit separate from that, and carried through until there is an understanding of what a license application is supposed to look like, and how the staff is going to review it.

MR. ANDERSEN: Yes, I think that is a fair comment, and I know that we have been working on -- that when Part 63 was being developed, we worked with Tim McCartin, because he was dealing with that, and trying to figure out how the agreements would change with the final Part 63.

And I know of at least two instances where after Part 63 was finalized that the agreements were null and void right after that. So we are constantly looking at how changes in our program affect the agreements, and I think what you said is very true.

CHAIRMAN HORNBERGER: Anyone else? Okay. Thanks. Andy, help me out a little bit with the schedule. Jim has another presentation on the integrated IIRSR.

DR. CAMPBELL: Yes.

CHAIRMAN HORNBERGER: And then Tim.

DR. CAMPBELL: Yes.

CHAIRMAN HORNBERGER: Well, I think what we will do is stick at least close to our schedule, which says that we are going to take a break now. We are five minutes early and so let's reconvene five minutes early to give us a little more flexibility for discussion.

(Whereupon, at 9:36 a.m., a recess was taken and the meeting was resumed at 9:52 a.m.)

CHAIRMAN HORNBERGER: Okay. We will reconvene, and we think that we have our high technology working again. So we will switch from overheads to power point, and again we are going to continue, and this time we are going to have a discussion of the integrated resolution status report, which was recently issued.

And Jim Andersen is going to do a presentation on that, and then we are also going to have a second presentation as part of that by Tim McCartin, who is going to tell us how some of the work on risk insights feeds into this integrated IRSR.

MR. ANDERSEN: Thank you very much. Like I mentioned in the first briefing, the Integrated Issue Resolution Status Report was issued in July.

CHAIRMAN HORNBERGER: Jim, you are not coming through on the microphone.

MR. ANDERSEN: Oops, I turned it off. Sorry about that. Like I mentioned, the issue of the

Integrated Issue Resolution Status Report was issued in July of this year, and the intent of this briefing is to provide the committee with some background on the document, and how it fits into the overall issue resolution process.

Before I get started though, I would like to give credit to all of the people who worked on the document. It wasn't by any means me. Most of the Center staff and NRC KIA leads, and other staff in the NRC, wrote most of the document and then Budhi Sagar from the Center coordinated it all down there. And I was the coordinator up at the NRC headquarters.

CHAIRMAN HORNBERGER: Describe the center, please.

MR. ANDERSEN: Oh, I'm sorry. The Center for Nuclear Waste Regulatory Analysis down in San Antonio, who is an NRC contractor. All right. The outline for this presentation, I would like first to discuss the report's purpose, and the status and structure of the integrated resolution status report, the content, and how it fits into the issue resolution process, and finally a summary.

And if you have any questions, please stop me, and I said that in my first presentation, but please feel free to do so.

Before we get into the purpose of the integrated resolution status report, let me give you a little background, and I think I am going to go a little further back this time than I did in the first briefing, and that is that in the mid-1990s, the high level waste program, the NRC high level waste program was realigned to focused pre-licensing work on those topics most critical to post-closure performance, i.e., the key technical issues.

As the issue of resolution process moved forward, the status of each key technical issue was documented in individual issue resolution status report, i.e., in each case, the key technical issue that was associated with the resolution status report.

And in Fiscal Year 2001 the NRC staff decided that the issue of the resolution process was mature enough to develop a single integrated issue resolution status report that would clearly and consistently reflect the interrelationships between the various key technical subissues, model extractions, and the overall issue resolution status.

The purpose of the integrated issue resolution status report was to write some background information on the status of the NRC and DOE pre-licensing interactions, and provide the technical basis for the staff's review presented at those meetings, and provide a transition from the key technical issue framework to the Yucca Mountain Review Plan, the draft Yucca Mountain Review Plan.

Next slide, please.

The current status of the document, like I previously mentioned, is that it was issued in July of this year, and the hard copies were completed in August, and the mails were mailed to the standard NRC high level waste distribution list.

The document was also placed on the NRC website under the NEUREG listing of currently issued new NEUREGs webpage. Next slide, please.

The actual structure of the document is as follows. The draft Yucca Mountain Review Plan format uses the same section headings, and the sections are broken down by the specific acceptance criteria for each section.

The integrated resolution status report discusses pre-closure, post-closure, and several other areas outlined in the draft Yucca Mountain Review Plan.

Some of the topics have not been discussed by the NRC and DOE, or the NRC staff has not reviewed applicable DOE documentation. Some sections are not addressed in this version of the document. It is also important to note that the technical information cut-off date was over in 2001, right after the last issue resolution, and the first round of the issue resolution meetings.

And so it doesn't cover DOE letters since that time, or the NRC's responses to those letters since that time. Next slide, please.

As I mentioned earlier, the integrated issue status report captures the results from the first round meetings, and incorporates final 10 CFR Part 63 in the draft Yucca Mountain Review Plan.

And it primarily discusses the information the NRC staff will need to conduct potential licensing review. The last bullet notes that the integrated resolution status report does not include information from the risk insights initiative.

It is important to note here though that that does not mean that we did not use risk information in coming up with the original agreements, or when we were writing the document.

We used all of the available risk information at the time that we came up with the agreements, and also when we were writing the report, but it does not include that specific information from the risk insights initiative.

Going into the contents a little further, in the preclosure safety area, the discussion is broken down into 10 areas, which correspond to the section between the draft Yucca Mountain Review Plan. Since the NRC and the DOE have only had one technical exchange on pre-closure, and that meeting only addressed a few of the 10 areas, much of the discussion in the pre-closure area is based on an NRC review of the documents that the DOE has already submitted.

The intent of these sections is to document those review and for the NRC and DOE to use that information in preparation for the future preclosure meetings.

Since additional public meetings are needed to address the remaining areas, it is possible that additional agreements would be necessary. Moving on to post-closure.

The post-closure area is broken down into four major areas; multiple barriers, features, events, and processes, model abstractions, and demonstration of compliance.

All four areas were discussed during two total system performance assessment integration, which is one of the key technical issues. There was a technical exchange in May and August of 2001. Agreements were reached in each area, and a discussion in the integrated resolution system status both focuses on information needed by the staff to conduct potential license review.

The next two slides discuss the model abstraction area in a little bit more detail. The model abstraction area is the bulk of the document, and if you have not seen it, it is about two inches or so, and the bulk of that documentation is the model abstraction. Next slide.

The model abstraction area is broken down into 14 model extractions discussed in the draft Yucca Mountain Review Plan, and the backup slides have a listing of the 14 model extraction areas for your information.

And also I did mention it earlier that there is the backup slides as well for the 10 preclosure safety areas, which are defined in the backup slides. In order to assist with the transition from the key technical issue subissues, to the 14 model extractions, each model extraction section identifies which of the key technical issue subissues incorporates the information from.

The sections also have an illustration which provides the overall relationship to the other model extractions. We tried to make it apparent how the key technical issue subissues fed into each of the model extractions in each of the 14 model abstractions and how they relate to each other. Next slide.

Continuing on with the discussion of the model extractions, the sections address each of the five acceptance criteria for the draft Yucca Mountain Review Plan, and a table at the end of each section that identifies which key technical issue agreements pertain to the specific model extraction.

So within these 14 model extractions the staff integrated the information from the specific key technical issue subissue, and the individual key technical issue issue resolution status report, and the first round of the issue resolution meetings.

Now, how does the integrated resolution status report fit into the issue resolution process? First, I believe it puts into writing the background for the agreements and why the staff feels that the information in the agreements is needed to perform a potential license review.

Second, it applies the draft Yucca Mountain Review Plan to the prelicensing process;

i.e., we tried to use the Yucca Mountain Review Plan in the pre-licensing process to show how it ought to work.

It is important to note here -- and I think it goes to the question earlier that if changes are made to the Yucca Mountain Review Plan, any subsequent versions, if we do in fact come up with a subsequent version, the integrated IRSR will incorporate the changes made to the draft Yucca Mountain Review Plan or a final version of the Yucca Mount Review Plan.

Now getting a little bit more specific, how does the integrated issue resolution status reports support the review of the agreements. Hopefully, the document itself provides detail of what information is needed and why is it needed. DOE can use this information to address the agreements as it bears further interreactions on the agreements, and the NRC staff can use it to look back on what we thought we were asking for at the time of the meetings, and document our thought process and why we needed the information.

And so we could use that information for further discussions down the road. In the pre-closure area, as I already mentioned, the information in this section will assist both the NRC and DOE in future discussions on the pre-closure areas.

In summary, I have just kind of provided a brief overview of the documents, and it is pretty hard to go into all of the technical details of the document.

I think that we have discussed in the past about having maybe another round of meetings with the committee on each of the specific key technical issues and have the issuees come in and give you a briefing on where they stand, similarly to like we did in -- I believe it was in January of this year, and that may be beneficial for future meetings.

But here I just tried to basically give you an overview of the document, and in summary I guess I would note that it does provide the status as of October of 2001.

It documents the technical bases of the intent of the agreements, and we are using it as an aid in transition from key technical issue subissues to the draft Yucca Mountain Review Plan.

So at this point I would like to ask if there are any questions that I can address. I may ask Budhi if it gets a little bit more technical to deal with this as well. Budhi Sagar.

CHAIRMAN HORNBERGER: Thank you Jim. Actually, we do appreciate that you gave us an overview and not a page by page description. Questions? Raymond.

VICE CHAIRMAN WYMER: Yes. You list four areas that are related to post-closure safety, and those are multiple barriers, features, events, and processes, and model abstractions, and demonstration of compliance.

It is easy for me to see how multiple barriers are related to safety, and how features, events and processes could be, and demonstration of compliance.

It seems to me that the model extraction is about one step removed from a direct relationship in a general way.

Certainly it is related to safety as it allows you to define what the dose of risks are. But it doesn't seem to me that it does not have the same stature as the other two. Could you just comment a bit on that?

MR. ANDERSEN: I am not sure that I am following you on the question.

VICE CHAIRMAN WYMER: Model extractions does not seem to be as directly related to post-closure safety as the other three things that you had listed to me. And I would like to have you comment on how the model extraction is as important as multiple barriers to the safety case.

MR. ANDERSEN: I think in the model extraction that we are trying to incorporate all of the information from the features, events, and processes, and various multiple barriers.

VICE CHAIRMAN WYMER: It just seems in kind from the other three items that you had on the list at this point, I guess. I would like to hear you elaborate on it.

MR. ANDERSEN: Budhi, will you go ahead, please.

MR. BUDHI: My name is Budhi Sagar, and I work at the Center for Nuclear Waste Laboratory Analysis in San Antonio. I think that this issue was discussed when we were formulating the YMRP. As Jim said, the sections in the IRSR are exactly opened in the same way as the YMRP.

At the YMRP time, we found that the model extraction has to be done in all of that as a matter of fact, and you had to do them if you went to a barrier section even in the MEP section, and so on and so forth.

So either we could have a model extraction and then have everything under it, but it was just a question of how you might be able to manage the discussion in the document. So I don't think that there is a unique answer to the way that we put it.

The model extraction in our mind had a very high importance because it is through a model extraction that you could determine whether even the multiple barriers requirements were met.

So we thought that it would be reasonable to discuss each one of the model extractions as a subsection.

VICE CHAIRMAN WYNER: Thank you. I would have actually done it the way you said it, and it is a possibility to put all the other things under the model extraction. It just made it seem to me to be different in kind than the three, but thanks.

MR. ANDERSEN: I am not certain which comments we got on the draft Yucca Mountain Review Plan, but maybe not. You would have to ask Jeff that question when Jeff comes up.

DR. GARRICK: Jim, you did a good job of telling us how an integrated IRSR activity fits into the issue resolution process. I am very interested in this point of view from the other way around, and that

that is that I see the integrated IRSR activity as kind of a real world.

You are really trying to resolve issues, and how does the process fit into the real world is my question. How much iteration did you do on the process as a result of the resolution activity?

MR. ANDERSEN: I am going to try to answer your question, but --

DR. GARRICK: Well, you had several slides talking about how the integrated IISR fits into the issue resolution process. Well, the process was created initially as kind of an abstract form, and now you have some experience, technical exchange of trying to resolve issues, and so the question is the adequacy of the process and how much adjustment to the process came as a direct result of the exercises that you went through.

I am going to respond and please let me know if I don't hit the mark here. But I think part of what we tried to do with the integrated IRSR is we had all of the KTIs and the KTI issue resolution status reports, and the KTI agreements.

And we took all of that and tried to integrate into the Yucca Mountain Review Plan format of the 14 model extractions. And in doing so, I think we were checking ourselves and the issue resolution process itself on was there any foils. Did we miss anything now that we are integrating all these KTI and KTI subissues together.

Was there any agreements that we missed, and was there any technical information which we didn't cover. So I think it was kind of a check on the first round of meetings where we were on the KTIs, and all the agreements that came out of those.

I think it was a check of those as we went through and tried to write these sections that the technicalese tried to their specific sections and incorporate all the information.

So I think that is how it helped aid the issue resolution process and it was kind of a check to make sure that we weren't missing anything as we tried to integrate this all together. Did that come close to answering your question?

DR. GARRICK: Yes. You see the Yucca Mountain Review Plan as part of a product if you wish of the exercises that you went through. In other words, all I am trying to get at is that you had to create a framework initially for how to go about resolving issues.

And now you went through and exercised

trying to resolve issues. Now, has that framework been influenced by that exercise?

MR. ANDERSEN: Well, I think it has been influenced in that I don't think we are going to use the KTI subissue framework. We decided not to do that in the Yucca Mountain Review Plan. We went to a different framework in the Yucca Mountain Review Plan.

So I think that that structure is already changing to some degree, and I think as we move forward and look at the comments to the draft Yucca Mountain Review Plan, and in doing the integrated IRSR, we may have some internal comments of was it easy to use as we tried to draft this document.

We may have some internal discussions, as well as format and things like that. So I think just viewing the actual document itself helped the issue resolution process move forward.

CHAIRMAN HORNBERGER: So it is just a slight or same track as John's question. So given your answer, do you envision that future technical exchanges with DOE will be focused around the YMRP framework, or the KTI framework, or is the KTI so entrenched that you will stick with that?

MR. ANDERSEN: We have had a lot of discussions internally about that, and I think where we are going is that we are going to just maintain the key technical issue framework just because all of the stakeholders are so entrenched at this point in prelicensing discussions that is at least initially where we are going to go.

CHAIRMAN HORNBERGER: In one of your slides, Slide 5, you mentioned that some of the sections are not addressed because the NRC-DOE interactions have not taken place. Does this mean that you are mainly referring to pre-closure activities?

MR. ANDERSEN: Mostly discussion pre-closure, as we addressed everything in post-closure. There is other areas in the Yucca Mountain Review Plan -- and Jeff, try to help me if I miss a few, but like training, and I think ET is mentioned in the Yucca Mountain.

And we have emergency planning that is mentioned, and we have had a lot of those discussions with DOE, and there is a lot of –- well, I shouldn't say a lot. There are some sections within the Yucca Mountain Review Plan which aren't addressed in this version of the document. If you just look at it from the preclosure and post-closure, it is all in the preclosure area.

MR. LEVENSON: Jim, I have a question that arises from probably my problem with the English language since it was my first language. For post-closure, safety has been very clearly defined by the EPA, whether you agree or disagree, and it is quantified and it is defined.

You have two slides in your backup, 15 and 16, where you talk about safety for preclosure. But no indication whether in this case safety means significant impact to the public, equivalent to a reactor accident, or at the other extreme, potential injury to one person, and more in the OSHA context.

What is the frame of reference for safety for preclosure?

MR. ANDERSEN: Correct me if I am wrong, but I would definitely say it is in the exposure to the public and to the workers. Tim is shaking his head. I don't think he needs to add anything more.

CHAIRMAN HORNBERGER: Questions or comments from anyone else? Okay. You were obviously very clear in your presentation.

MR. ANDERSEN: Or very confusing and no one can understand it.

MR. HORNBERGER: And as I said, we have a continuation on the integrated IRSR approach, and Tim

McCartin, I think, is next on our agenda, and Tim will tell us how the risk insights initiative is contributing to the whole integrated IRSR process.

MR. MCCARTIN: Good morning. The title for my slides or my presentation is fairly long, Framework for Staff Analyses to Support Pre-Licensing Interactions and Issue Resolution.

What it really points back to is that Jim indicated during the process of issue resolution and risk insights initiative that analyses were done. However, the committee will remember back in the presentation on the risk insights that a number of other staff used other measures other than risk when they were prioritizing what was called risk insights.

At that time we recognized as we moved forward with issue resolution that we needed to do a better job of laying out a process for what calculations we are going to do, and why we are going to do them, and how they fit into the regulations, and to provide staff insights, quantitative insights into the performance of the Yucca Mountain repository.

And that is basically what I am going to try to do today, and we are in the process of developing this framework, and I guess there are two questions that I would pose to the committee.

We don't necessarily want a letter, and we don't or we can't stop you from writing a letter, but two things if you could, and two things at the end of the presentation, two questions that we are interested in.

One would be does it look like we are headed in the right direction, and two, we are in the process right now of developing this framework, and we will be more prepared for a possible presentation in November, and would the committee like a more detailed presentation of where we are headed in the November timeframe.

And with that, let me go to -- I will touch briefly on the background of some of these analyses that we have done over the years and talk to the framework, and I do want to give an example calculation of what I mean by this framework and how or what kind of calculations that we might do, and with that done, the next slide.

Boy, that is hard to see from back here. The background basically is that we have conducted a wide range of analyses, many of which get presented to the committee and other forums for understanding the repository system, evaluating factors that affect the timing and magnitude of the dose.

And looking at key assumptions, and we have NEUREG publications that go back 15 years when we first did our initial performance assessment for a potential repository at Yucca Mountain. We have had the ACNW presentations on these results certainly for the past 15 years in conference proceedings.

All this information as I said is being used to support pre-licensing interaction. What we found, however, I would say in the risk initiatives that too much of that information was in the experience and minds of the performance assessment analysts, and not that much was being presented to the other technical staff that was useful.

Typically all that is being presented are dose numbers, sensitivity to dose, and there is a lot more information. As Jim indicated, we have the multiple barrier requirement.

There is a lot of things that need to be developed to understand the performance of a complicated system like the repository, and that is what we are trying to get at, and with the next slide the framework is looking at what kinds of analyses we could do to understand the repository behavior, including performance of barriers, and risk significance of parameters and models.

And certainly understanding the effect of uncertainties on the performance of the repository. And why do we need an analysis? We really need a framework for this analysis to make sure that we have a comprehensive treatment of all the issues and also just as important, an appropriate context for the analyses.

I will point to a comment that you made, Dr. Hornberger, at the last meeting. You saw some of our analyses, and I will paraphrase; the numbers are interesting, but what does it mean? We did not have a good answer for you.

In just doing an analyses, if you can't put them into the context of why are you doing it and what is it showing, just doesn't make a lot of sense.

We need to be able to do a better job to communicate the information that for the most part I would say in the heads of a lot of the PA analysts and not really being communicated to review committees or cells, and I think the same is true for the NWTRB.

I think the analyses aren't conveying as much information as they need to convey, and developing this framework we think is important to lay out the context and how it will be used. Next slide.

Right now we can develop four broad

categories of where we will be doing analyses. The easiest one clearly is the overall performance of the repository, and that is pretty much what everyone is focused on, and meeting the 15 milligram all-pathway limit.

Next is the capabilities of the engineering and natural barriers, a requirement in our regulation. That is underlined, because that is what I will give a particular example for that aspect.

I am not going to have any examples for the other three, but once again in November, there is a lot of information that I could talk to for all of these, but I am merely focusing on one aspect of the engineered and natural barriers.

Then the effective uncertainty and parameters and mods, at the last meeting you saw a lot of work on the sensitivity and uncertainty analysis, and then of course the effect of potential limitations on the technical bases.

And there is a wide range of analysis that you might do there. I think we would put the degraded barrier analysis in that particular bin, where you are looking at the effect of that you might not be as smart as you think you were.

You may be wrong and degrading a barrier and possibly neutralizing a barrier, and would be looking at I think that and where those kinds of analyses would fit.

And that's what I mean by I think it is important to establish a framework, where you put why am I doing this calculation, and what is it pointing to in terms of the regulations, and what do I hope to get out of the results, thereby -- and I would say from the staff's standpoint, we are going to be fairly critical internally, in terms of the analyses that people are doing.

Okay. You are telling people that you are doing it for this reason, and here is what you say you are going to learn. And then the next thing is that the numbers that you present, and the curves that you display, are they really doing what you are telling me what your intent was.

And if they aren't, maybe you need to think a little harder on how to present the results and what needs to be calculated, et cetera, and that is part of this framework.

We want to be sure that the results are actually providing useful information, and not just putting up numbers that people are left with, well, okay, interesting, and what does it mean, and everyone is going to walk away with a different interpretation.

And I think that it is important that the numbers and the results can convey useful information. And then with that, we go to the next slide, and if I expound a little bit more on one particular aspect, and that is the capabilities of the engineering and natural barriers.

We are looking at an evaluation of the barrier capability as represented in the performance assessment model, and that is really -- and a slight diversion. If people wonder why in the Yucca Mountain Review Plan, for example, we have talked to or we have barrier capability first before we go into the model extractions, et cetera.

Clearly, you can't do that until after you are done with your analyses, but the reason that it is up front in the Yucca Mountain Plan is that we want the Department to tell us initially what are the barriers, and their capabilities, and what are they relying on.

So we can then when we go in to reviewing the model extraction, we sort of know what the story is already. We know how it ended, and we will look at the model extraction to see if that model extraction support the story they have told us is the bottom line up front.

Also importantly, we can use our particular information that we have developed on barriers to inform our view, and we may have a different of opinion in certain areas of the barriers, and we can bring our information into that up front part to then help guide the rest of that review.

And that's why the barrier capability is up front, rather than at the end. With that said, in terms of regulatory context, there is a requirement that a repository be compromised of both natural and engineered barriers, and the regulations require that the capability of the barriers be described.

And that the definition in the early part of the regulations speaks of it and it is capability to limit the flow of water, or the flow of radionuclide to the release radionuclides from the waste package and waste form.

So with that, let me go to why would we do these barrier analyses, and that is the context, and that is what is required. Number 1, it requires an independent evaluation of DOE'S description of the barriers. As I said, DOE, up front, will describe which barriers they are relying on.

And we have our own barrier calculation to also what is our understanding of the repository system. I think most importantly why is it up front? I think that second bullet says it all. The barrier capability should assist the interpretation of the performance assessment results.

I believe describing the capabilities of the barriers will allow you to understand why the dose numbers come up the way that they do. And finally and certainly identifying the significance of the barriers allows us to focus our review and concentrate on those things.

There are many different ways to describe the barrier capabilities, and I have three cables that follow. If I knew power point better, all three might have ended up on the same slide, but I couldn't figure out how to do it, and so they are separately.

But what I have done is try to give information in terms of what I will call as a delay time in years, and so those numbers that you see are a delay in years.

And I think I can explain the results with these kinds of -- with this information, and clearly the first barrier is the waste package, and the waste package is the easiest to understand. It is primarily a binary system.

It is either leaking or it is not, and if I look at -- and for this particular analysis, and I realize that there is uncertainty with each of these parameters and results, for these I have tended to use a mean value representation.

And we certainly are looking at expanding and have uncertainly bands, and a range of the lifetime under the waste package, approximately 50,000 years is what we have in our TPA code for the waste package lifetime.

And you will notice that I think a key part of the delay time is that you need to look at it radionuclide by radionuclide. The behavior of each barrier can be drastically different depending upon the radionuclide.

For the waste package, obviously it is not. It either leaks or it doesn't leak, but why did I pick this particular suite of radionuclides. Well, the first three, technesium, iodine, and neptunium, are primarily the ones that show up in the early doses.

The next three radionuclides, the two plutoniums and amorisum, make up approximately 97 percent of the inventory by curies, and that is the thousand year inventory.

So that actually represents almost 97 percent of the curie mode of the entire repository. Uranium, you will see -- and as to those percentages are the percent of the thousand year inventory that you see below the radionuclide.

Uranium is a very small percentage of the inventory by curies; however, by mass, it does represent 99 percent of the mass of the repository. So why I could do it for every radionuclide, this captures most of the curies and most of the mass, and the nuclides that primarily contribute to dose as a first cut.

And the waste package, like I said, looking at mean values, approximately at 50,000 half-life, if I go to the next slide, which is –- and now to try to get some insight on releases from a single waste package.

And for this I am just looking at what kind of characteristics are there for the processes that affect release, and I am looking at a single waste package.

And the question was how much, in terms of delay time, how much stuff, how many curies, have to get out of the waste package for me to call it a delay.

And for these particular numbers, what I use is how long did it take from the time when releases started to occur until a curium load for that nuclide that would cause a 15 milligram dose if it was all placed in a 3,000 acre feet of water in a single year.

Now, this you will see for not too surprising, if I look at a release rate of 10 to the minus 4 per year, technesium iodine, which are very small inventories, and the release rate is very effective in that thousands of years of release at that rate before you would get enough -- if it was all compressed into a single year would give a 15 milligram dose.

Other nuclides, obviously the amorisum and the two plutoniums that are a very large percentage of the inventory, it virtually takes very little time before essentially the first year, and you are going to get enough to cause a 15 milligram dose. Uranium is quite a bit longer.

If I look at solubility limits alone, you can see technesium and iodine are very soluable. So if I have 10 liters per year of water going out of the waste package as the soluability limits, that would be sufficient to give a 15 milligram dose for technesium iodine.

And if you go for the other radionuclides, uranium is one that, gee, it is far greater than a hundred-thousand years before you would ever get enough of, and even if you accumulated all of that hundred-thousand years of release into a single year, it still wouldn't get 15 milligrams.

And so it is a way of understanding by radionuclide what is causing the results to be the way that they are. You can see the soluability limits, and you would rarely ever expect uranium to be any type of significant contributor.

Now, in addition to this, this was done as much as a hypothetical calculation and I just assumed the release rate of 10 to the minus 4 per year. I assumed the soluability limit of X, and I can do this calculation. This was a hand calculation.

However, what we would intend to do is the gosum model, as well as our TPA code, and we can do this calculation and see, well, how long does it take. A 15 milligram, a curie model equivalent to 15 milligram to get out of the waste package once it starts to fail.

And you can get a sense of, well, gee, it is either going to be a release of rate of soluability limit, and if you see very small numbers, neither are effective.

But you can go back and look at what is going on for that particular radionuclide, and it is a way to understand the results. Going to the third table, in terms of the release from the geologic units, the natural barriers, there I actually chose a slightly different measure, and this was done with our performance assessment code.

And we could do the same thing with the gosum code. They have similar kinds of outputs. But I looked at the first time step that mass entered in a particular barrier, and when did that mass get out.

Whatever it was, and if it was a millionth of a curie, or one curie when in at TX, and how many years before that amount came out. And once again, not surprising, you can see that I have actually four -- I split the unsaturated zone, and saturated zone into four particular aspects.

The first one, the UZ total, is what do I get with the unsaturated zone the way it is represented in our TPA code. The second, the UZ, is Calico Hills, non-welded vetric only, is what do I get if I just look and use exclusively the Calico Hills non-welded vetric.

It is a porous unit, and tends to be fairly slow water movement, but also fairly significant retardation. And then the saturated filled rock is the fractured rock, and the saturated zone alluvium is the alluvium, and what you see there once again for many of the radionuclides, there is significant retardation in the unsaturated zone, and the saturated zone, and you can see you get greater than hundreds of thousands of years for a number of these radionuclides.

And this also points to -- part of the reason that I would like to explain these results this way is that in terms of the barrier one off, one on, analyses, that we have done are very, very difficult to interpret when you just show a dose number.

And I think you can see where for some of our calculations the unsaturated zone and both the unsaturated and saturated zone basically have the same function.

They can delay certain radionuclides greater than a hundred-thousand years, and there is a lot of effects like that, where when you do one off and one on, you have to be very careful not only as to what are the other barriers that I have and what are they doing, et cetera, but this allows you to just look at what is this barrier doing by itself.

And I have a depiction, and to me I looked at these results and it is not surprising that I see iodine technesium as dose treaters. You can see that they are unretarded, and they tend to move relatively fast, and there are other radionuclides that are retarded for significantly long time periods, which is why you never see them in the dose calculation.

And that's also the other part that I know is sometimes hard to convey with the dose number. You can change or you might get a lot of iodine, and a lot of technesium, and it may be more with a different kind of calculation, but you don't have a sense that, well, in both of those calculations I never saw any amorisum or plutonium.

And it is a way that we think you can then go in for each one of these, and what kind of risk information, and I would go back to the KTI leads for particularity, and radionuclide transport.

I know that I have heard laments, well, if the waste package fails, nothing I have is important. And I was adamant that that is not true, and I think this does show that, well, look, a huge portion of the inventory, and a massive repository, there is tremendous retardation. Is that true?

We have KDs here, and the department has KDs here, and are those KDs -- what is supporting those KDs. You might be able to do more detailed process models to support that. You might have experiments, and field experiments that have done this.

You might have natural analogs, the pina balocua (phonetic) with uranium that supports some of this stuff. If you believe these retardations, and some of these delay times, I feel that you then can believe the dose numbers coming out of the performance assessment code.

And so I think there is a lot of -- we are looking at how best to develop some of this information, because in addition to this, it is what kind of information supports these values. What is the uncertainty, et cetera, for some of these, and we will be working on that, and could have more for a November meeting.

As well as the other categories that we think are important, and in summary, what the bottom line is that the complexities of the system, the long time frames, the uncertainties, require that we have the flexibility to do a variety of calculations.

As I showed for just that relatively

simple example, I had three kinds of different ways of looking at the different barriers. They all provided some insights and they gave me additional understanding.

And we don't want to be locked into any particular set of analyses to do or not to do. We want to stay open and challenge ourselves, and what kinds of analyses are giving useful information, because each analysis provides answers typically to specific questions.

But the bottom line for the framework is we really need to make sure that we appropriately define our analyses in terms of the intended purpose and the application of the results to the regulation, and that is what we are going to try to do with this framework, and why we are doing it, and how it fits into the regulation, and the kind of information that we are learning.

And we think that is historic for helping out the KTIs, in terms of the risk insights, because those first meetings that there just wasn't enough -- I will say fundamental understanding.

Just seeing a dose number to me is not sufficient. It doesn't carry enough information, whereas, delay time, you can test this. You can look at the experimental information, and like I said possibly analog information.

And you have a basis for challenging whether you believe that is correct as it incorporated the model uncertainty, et cetera. And with that, I would be happy to answer any questions.

CHAIRMAN HORNBERGER: Thank you, Tim. Raymond.

VICE CHAIRMAN WYNER: No questions.

DR. GARRICK: Tim, how close does your analysis come to the case where you would carry the equivalent of a single waste package of spent fuel into the repository in a paper bag and leave it there, and calculate the dose at the critical groove, versus doing it in its waste package?

In other words, this looks like a very valuable step in terms of getting a better understanding as to what the risk is, and what it means, and where it is coming from.

But I think what would even be better would be if you put a waste package equivalent in the repository with no waste package, and did a time dose calculation by the same radionuclides that you are considering here, versus with the waste package.

And are you moving towards that kind of

analysis, which I think would have some real meaning, because then you could see the uncertainty, and you could see the dose is a function of time, and you could see what it actually is, rather than necessarily dealing with the question at the time at which this 15 milligram or whatever.

That it just seems to me a much more direct measure of the concerns that people have.

MR. MCCARTIN: Certainly analyses of that type could be part of the framework, and where I looked at the limitations of the technical basis. We could do something greater than analyses, and some of the stuff that Sid Cohanta and Richard Cardell presented, gave some of those things, although if you are suggesting a single waste package, versus all the waste packages –- I mean, there is the flexibility to do that.

I would say that part of what I see here is that from the geologic barriers I will say that I was actually –- I should have expected it possibly, but I was pleasantly surprised when I did the delay time for the natural barriers, I did them for a single waste package in all the waste packages, and the delay times were exactly the same in that particular -- it did not – they were degrading the way that we had it in the TPA and not a paper sack if you will.

But the initial amount, more went in initially at the time of failure with all packages, versus one, but it took the same amount of time to get out of the natural system, which isn't too surprising.

What that analysis would say is that for many of the radionuclides, they are not going to get out in 10,000 years. You would see a zero dose; i.e., technecium would be there.

DR. GARRICK: But what we are trying to get at here is what is the truth, and what do we expect to really happen? The more we go in the direction of abstract interpretation of that, the more difficult it is to see what is exactly taking place.

MR. MCCARTIN: Right.

DR. GARRICK: It just seems to me a very simple way to get to the question is that you put the waste on the top, and you don't put it in anything, and you do the calculation, and you answer the question of how good is the geology as a protective barrier.

And then you really know and have a baseline against which to assess the waste package performance, and as far as I know that has not been done, and I don't think that is a very difficult thing to do.

And that is really a basic question, and would -- and especially if you did it in the right forum, you could display the uncertainties, and you could see the sensitivity to different assumptions about retardation rates, and it would very explicitly answer the question of the quality of the natural setting in terms of being a barrier.

And I don't think that has been done, and I don't know why not, and it is something that could be done.

MR. MCCARTIN: Well, different groups have done different analyses of that type. Remember, there are a lot of assumptions and the reason that I -- well, I am not so comfortable with the dose phase ones and the material will not be in the tunnel without a waste package. And you have to assume certain –

DR. GARRICK: Well, we are trying to answer questions. We are trying to answer performance questions about this repository.

MR. MCCARTIN: Yes, I understand that, but I will guarantee you that I will make assumptions in the code about the chemistry inside the waste package, the degradation rates, and when I don't have a waste package, what do I assume.

And once again, there are many assumptions that the analyst will give that you then have to go through a lot of explanation --

DR. GARRICK: But it is a lot simpler when you don't have a waste package. I mean, I think the model is much simpler, and now indeed it is a geochemical problem.

MR. MCCARTIN: Well, I will have to make an assumption about how much water and how it contacts waste.

DR. GARRICK: But you will have that no matter what. You know, the 800 pound gorilla is water, and if you don't have water, you don't have a problem.

And so all I am saying is that if you really want to get an answer to this question, calculate it, and we seem to keep trying to back into it.

And as far as the complexity of the model is concerned, I don't see that as being any more complex than what has already been done.

It is not what gets out of the waste package, but what is the seed, and the seed is the natural setting. You have to answer all of the questions that you just postulated as being questions that you have to answer if you took it in there in a paper bag.

So what is the big deal? I saw at the Technical Review Board some calculations to me that were pure nonsense. There were not answering the fundamental question. They were taking the position, well, what if we have no barriers, and what kind of doses do we get.

Well, what a silly question. We know that we get catastrophic dosages, and we know that the amount of information that that communicates to the public about the performance of the repository is essentially zero.

It seems to me that what we have to start doing more of is asking ourselves what is the realistic conditions that exist here, and how does it respond to those conditions on what kind of doses that we get.

I think this is a very valuable calculation that you have gotten and it provides in my opinion far more insight than what we saw at the technical review board.

And it is much more up to standards, but it still is kind of not addressing the question directly as it could be, and that is my point.

CHAIRMAN HORNBERGER: I liked your

analysis, Tim, and I think that John and I are going to have to arm wrestle because I have never been a fan of the paperback scenario.

It doesn't seem at all realistic, but I am sure that John can explain it off-line to me, and we will try to explain it to you afterwards. It is interesting to me that basically you are proposing some different measures, and so we have to focus on those that are most clearly related to risk.

The time delay is not quite so directly related to risk, and I think that perhaps that is part of the question. Have you thought about any other possible measures?

I mean, in substance, it strikes me that you are going in the direction of looking at human input analysis, versus human output analysis for different barriers, and looking at time delay as a measure, and are there other measures that you considered?

MR. MCCARTIN: Right now the field is wide open, and we are trying to -- I think that the committee has pushed us and this is one step. We are in the very beginning part of it, and we are trying to look at other things that we could be calculating that would be equally or more useful than this.

And right now I will say that this is the first step, and this got a lot of people thinking. There are a number of people at the NRC and the center that are engaged in developing the framework and thinking about what other things we can do.

Right now I don't have any specific examples for you. This was an initial one that, like I said, the part that I liked is that it provides me some understanding of what is going on, and I realize that it is one step away from the dose.

But if I don't believe these things, there is certain -- I can look at this and like I said, iodine technesium, what was the reason that we see that, and how about these other things? I mean, there is a chance that we will never see them.

And that is equally as important, because when we look at the PA, and one might look at the KTI agreements, and maybe they are not all of the highest risk importance. Not everything can be of high importance.

But in terms of analyzing the Yucca Mount system, you need to have a credible model, and you need to have things in there that give you a sense, yeah, I need to know that, and I need to know that it did not have a big effect, and I believe that.

And I will point to the retardation factors for some of these radionuclides. They are never going to get out. We need to know that those KDs are supportable. You need to be able to defend the zero.

So you will see things in the agreements and in the models that don't have or don't rise to in a sensitivity analysis as, oh, that is not important. Well, okay, I will say that with our analyses that you will not see a KD for plutonium or amorisum as important to performance ever. I don't think so.

Well, that is 97 percent of the curies of the repository, and it never gets out because of that KD, and that is what this tells me. We need to verify that. It may be easily verified. These nuclides are strongly absorbed in geology.

But I think there are aspects that while removed from what actually causes the dose are still important to be able to have confidence that the calculation is correct.

CHAIRMAN HORNBERGER: Phil.

MR. LEVENSON: Tim, you know, there is some things that I tried to avoid saying in public, but sometimes you have to say them, and in this case I would like to commend you for really getting started on what I think is a very unusual thing in today's world.

I am old enough that I used to think what is important, and understand what was happening, and not just what a computer calculated. This is a very good start towards an understanding. I have two questions.

One is do you intend to expand this to take a look at the preclosure activities, because some of us feel that looking at the Yucca Mountain Review Plan that that is not very much focused on public safety.

There are too many things in the Yucca Mountain Review Plan which have a potential to damage or injure one employee maybe, and it seems to me that focusing on public safety would be an important issue and I wondered whether you had an intention to move in that direction.

MR. MCCARTIN: Well, along the lines that –- and I appreciate the compliment. The bottom line of our regulations is we need to understand, the DOE needs to understand and present the information of how the repositories behave, preclosure and post-closure.

We also need to understand why, and I would say that obviously delay times don't really have a lot of meaning preclosure because most of it is going to be --

MR. LEVENSON: But it is the concept of let's understand.

MR. MCCARTIN: Yes, in terms of what nuclides are causing the dose, and why, and what aspects of the potential accident that causes that, yes. Yes, I think that is a good suggestion.

We haven't to date –- I mean, this was primarily a post-closure concept, but I think it is a good suggestion to expand it to pre-closure.

MR. LEVENSON: And the second question is that it looks to me from the numbers on the table that you analyzed this for spent commercial power reactor fuel. Did you at least superficially? But that's not all that goes into the repository.

There are large volumes of vitrified waste, and there is Navy fuel, and there is spent research reactor fuel, and there may or may not be excess weapons, plutonium, depending on which political party is in power at the time when you start loading.

Do any of these other things have any impact, or does the commercial nuclear fuel just overwhelm it all?

MR. MCCARTIN: Generally, we believe the commercial spent nuclear fuel provides a pretty good bound. However, we are -- certainly the Department has glass in theirs, and there is a lot of technesium in the glass, and so there are some aspects that could be collards with glass, et cetera.

So there are things that we will look into, but we have not gone that deep into this analysis, but clearly or certainly plutonium collards, you can see that the geology, that it retards it very well, and collards is a way that is defeated.

And one thing that I would like to point out, because is fairly important, but when I did the two UZ, one with the Calico Hills vitric only, the Calico Hills vitric provides a lot of retardation, and how much vitric is under the land repository.

Our current PA model has approximately 50 percent of the footprint where there is Calico Hills non-welded vitric below it. The Department, I believe, has more. But this is another way that shows you that this is a very important assumption, at least as we understand that particular portion.

VICE CHAIRMAN WYMER: You asked us to answer two questions, and I can answer for myself here. Are we headed in the right direction? The answer is yes.

I think that you have got a lot of good insights into what is really going on from this stuff, and we want a more detailed discussion in December, or I personally do, and I would like to suggest if it is at all possible that you try to put this sort of thing in the context of risk.

You can take it one more step, and I say that because I think that it is very sophisticated what you are telling us with respect to analysis and understanding.

And I think that most of the public that are not technically trained would have a hard time following it, but they do understand risk and they do understand dose.

So if you could expand your scope a little bit, and put this into a larger framework so that they can relate to it, then that would probably be worthwhile.

DR. RYAN: Thanks, Tim. I enjoyed your presentation. I guess I will start with seconding Ray's comments to answer your two questions. Yes, I think it is a great direction, and two, I would love to hear more about it.

Let me go into a little bit more of detail with you on a couple of points just to maybe expand and give you some things to think about. Your examples, and I recognize that you are in the early stages here, and so this is not criticism, but is more of a suggestion.

And that is that the first one is that I am not real sure from your explanation what this 50,000 years across the board really means.

MR. MCCARTIN: It is just the mean failure time for the waste package to corrode.

DR. RYAN: I've got you. Okay. And it led me to this thinking. For each one of these examples or any others that you developed, I think it would be very helpful to define the question that you as the analyst are intending to answer.

I think it is also important to bound what that question is and say what it is not trying to answer. For example, you show that Technesium 99 is a soluability when it shows up in a year when delivering a 15 milligram dose in a year.

As part of good communication, I would want to constrain that to say that is not the same as the whole system performing for one year, and to be very clear about what it is that you are trying to answer in this comparative way with each one of these structured questions.

And so I think to get to dr. Garrick's point, and if you then look at the structured questions that you are answering, you can then roll it up to what is important and what the risks are. You can look at dose consequences, perhaps, as scaling factors, and those kinds of things.

You can really do a lot with this analysis to dissect for lack of a better word the whole big global calculation to dose, and look at what is contributing and what is important, and what parameters drive it, and which ones don't.

And I think as you have pointed out a couple of times, then focus in on, well, we need to know this particular KD, or that particular unit thickness, as kind of key technical data points that substantiate the entire calculation.

So three cheers and keep going and let's hear more about it. I think it is a great approach. The other folks can cover the other points, but I think that is real helpful.

My main point I think that is a key emphasis for me is to really define what question, what analysis point, you are trying to answer with each one of these sub-analyses, each one of these points, and then say how that is bounded, and what it is not intended to analyze.

And that would be a great way to communicate it both technically and I think more to the public about how you are thinking through your analysis. It is very helpful.

MR. MCCARTIN: And along those lines, in November or December -- and I will gladly put it off a month. No, there is always work to do. As we go into more detail, and that is what we are hoping to present. Here is the kinds of things that we would calculate, and why, and why not, and giving the committee feedback on that, and possibly additional analyses as Dr. Garrick suggested.

And for this meeting, we just want to give a little bit, recognizing that we have a lot more that we can present then.

DR. RYAN: Well, this is a good taste of what is in your mind at this point, and again I would suggest that you take all the questions that you want to answer and how you want to divide up the pie, and then think about it, and am I touching all the issues, and how do I present these lists of questions in these little analyses to give a more comprehensive picture of your analysis process, and that is really helpful.

DR. GARRICK: And I would add to what the rest of the committee has said as far as the answers to your questions. This is definitely moving in the right direction, and we want to hear more about it in the future.

One thing that I would hope that would also be posed as you move down this particular pathway is the contribution, radionuclide by radionuclide, and in the context of uncertainty.

My naïve sense of all of this is that the uncertainties that are ever so much greater in the natural setting than they are in the engineered setting.

And I think that is a very fundamental and important point, that somehow we have to capture in these kinds of exercises.

MR. MCCARTIN: Agreed. And these obviously are primarily mean value type calculations, but the system is far more complex.

MS. LEVENSON: Tim, I guess I should give you the reason why I raised the question of preclosure, since post-closure is at a minimum 62 years from now, I expect to be off the ACNW by then.

CHAIRMAN HORNBERGER: Does the staff have any questions? Mike.

MR. LEE: Mike Lee, ACNW staff. Tim, as your thought process continues to evolve, is some thought being given to how this might be integrated into the Yucca Mountain Review Plan or would it be appropriate to integrate it in the Yucca Mountain Review Plan?

MR. ANDERSEN: It certainly is relevant to the review plan, and whether we would necessarily put particular calculations that we would do as part of our review, and write them in specifically in the review plan, it is on the table, and we haven't really talked to management about that, and whether it would be in or out.

The one thing that -- and maybe it is not a problem, but when we start doing these analyses -- and once again, each one of those three I did it a slightly different way for particular reasons.

And you want to have that flexibility to what seems to make the most sense, and what provides the most information. But in a broad generic sense, maybe some of this could be in it, but the key is that we need the flexibility to do whatever analyses we need to help provide the information for making our licensing decision.

CHAIRMAN HORNBERGER: Other questions? I

think that Budhi had a comment or a question?

DR. SAGAR: Budhi Sagar, ACNW in San Antonio. I thought to give a brief thought to Mr. Levenson's comments on the preclosure. I think we would have to carefully look at the comments are when you say that some of the YMRP write-up or acceptance criteria review methods are not focused on public safety.

But there are numerical and quantitative requirements in preclosure, just like there are in post-closure. And at the boundary of that, and the geological repository operations area, the dose to the public, a member of the public, for example, is not supposed to exceed 15 milligrams per year.

There is a different dose limit for the workers, and the YMRP's focus is on identifying what are the structure systems and components that are important to meeting that criteria.

And that is the acceptance criteria for identifying those systems and components, and analyzing the design as presented by the Department. But I just wanted to clarify that the public safety is indeed the central theme, just like in the post-closure.

But maybe in the detailing we missed

something or saying something that should not be said, and that of course would have to be looked at in detail. Thank you.

MR. LEVENSON: I know that there are many other requirements. My point is that I think the YMRP should focus on public safety, and it doesn't mean, for instance, that DOE doesn't have to conform to OSHA requirements.

It doesn't mean that you don't protect the safety of the worker. But I think that all of those things are inherent, and are understood, and I am concerned that there are limited resources.

The center has limited resources, and the NRC has limited resources, and when you spend them on things that are less important, then there is less intention to what I think are the most important, and I think that there just needs to be finality primarily on public safety in this type document.

MR. KESSLER: Don Kessler, EPRI. I wanted to thank Tim for continuing to further the clarity on what is meant by a barrier, and how one does an analysis for the barrier.

I guess to take John's other arm, since you have got his one arm there, George. I would argue that while you can do delays for barriers, what really matters is why do we care if there is a deal, or if we get past 10,000 years, but in terms of safety, we think in terms of dose right now, and that is the way the regulations are written. So what can be done in terms of dose?

Well, for example, to follow John's example, one could do the analysis, and I believe DOE has as we have, where you look at what if basically you are doing the equivalent of putting the waste underground, and not in any kind of container, and not with any engineered barrier and do that analysis.

That provides you a dose number, but is the dose relative to what? It might also give you a delay number, and so you have to go back and compare it to your base number, and that's fine.

When we do that sort of analysis, we are suspending our disbelief. We are basically saying that none of us believe that the waste package -- well, maybe some of us feel we are being optimistic about its performance -- is going to have absolutely no effect, and I think that's what Tim was trying to get to with one of his comments.

So the idea that we do need barrier analyses, we are already suspending our disbelief. Certainly in our EPRI analyses, we went to the complete suspension of disbelief, and we are trying to add barrier by barrier to try to get an idea of its dose, which is what was presented at the TRB meeting, but also we get the delays.

And in fact in the past two EPRI reports, there has been tables in there of the dose reductions, and it is not appropriate particularly to look at the absolute values. But what you are looking at is the relative reduction in doses as you add barriers.

In addition the delay time, in terms of when that peak would occur by adding barriers. To me, what I think Tim presented, and what that kind of analysis is, are mutually supportive and can also get you insights into how much one barrier affects another, and how much an individual barrier contributes.

Certainly we can look at individual barriers in terms of delay as Tim has done, and that is very insight, and thank you, Tim, for doing it in a clear way. But if you add the two, you can get additional insight in terms of putting the barriers into context.

CHAIRMAN HORNBERGER: We have time for another question or comment.

DR. GARRICK: One thing I wouldn't want to be misunderstood, is that I believe in realistic analyses, and my whole crusade on this committee has been to be realistic.

People keep calling things risk assessments that are not risk assessments. The fundamental cornerstone of a risk assessment is the concept of likelihood.

If we do not somewhere along the way address the issue of likelihood, then we have no reference or baseline to think in terms of what constitutes being conservative, or what represents uncertainty or what have you.

So I am not pushing that we do unrealistic analyses, but I do get back to what Mike Ryan was suggesting, which is an excellent suggestion. And that is what is the question that we are trying to answer. If we want a good answer on the quality of the natural setting as a containment barrier, there are very much simpler ways to do that than some of the ways that we have been approaching.

And all I am saying is that if that is an important question, then we need to answer. I think the approach that I prefer overall that it is a systems problem.

It is a combination of an engineered

system in a natural setting. That is our system, and we should keep that in mind and not necessarily separate it unless somebody wants to answer questions that is enhanced greatly by its separation.

The problem with those kinds of calculations is that they get to be taken as something much more than they were intended to be, and so the whole concept of this communication goes into a tailspin.

And I am perfectly aware of that, and we don't want to do that, but we are trying to answer these basic questions, and my only point was that there are ways of doing that.

MR. VAN LINK: Dave Van Link, DOE. In fact, we were struggling with the chart that was shown at the TRB by Peter Swift, which showed our one on analyses that were asked for by the technical review board to put into a presentation that will be given by Dr. Dyer on Friday at the Reno conference.

I think it is the AIG, American Institute of Geology. In that struggle of how to present that to the public, we decided to do pretty much what you were suggesting and take out some of the really hard to explain curves.

And so what we have is -- let's assume

that bare waste is put on top of the mountain. This is waste as we see it. It has gladding, et cetera, and it has some properties. We calculate the dose from that, and it is pretty darn high.

Let's take that same waste and put it in a drift. No waste package, no engineer barrier, but let's calculate that dose, and it turns out to be a little higher than what we showed at the TRB, and I am going to send them an amendment.

The checking process is wonderful and it does find little glitches here and there. But this points out the point that Tim was making, is that when you do these analyses, you are pushing your finely constructed model outside the bounds for which it was constructed, and you will get oopses (sic) when you do the checking later.

And hopefully you do the checking before you are presented with the results, and then you get that dose result, and then the final one is the base case, where are all of the barriers are in place.

And I think what it does is that it gives a fine indication of, yes, the natural system does provide protection, and when you are finally done, yes, the total system is achieving a goal of safety for the public.

And I think that is the basic message, and this is the reason that we are showing this in this particular meeting. That is the basic message that we want to present. That is not a basic message for the review of a license application though.

That is important, but not sufficient, and we want the other curves to show what the importances are, and we want to pay attention to what Tim is saying.

CHAIRMAN HORNBERGER: One final question in the back here.

DR. HORN: Hi, JoAnne Horn, Lawrence Livermore National Lab. I am not a geochemist, but it was my understanding that your calculations were completely based on soluability constance. In other words --

MR. MCCARTIN: The one table on release from a single waste package, I did do a calculation where I assumed a particular amount of water going into the waste package, and just using a soluability --

DR. HORN: Right.

DR. MCCARTIN: But that was --

DR. HORN: It was through the geological barriers, and do they include absorption of colloidal transport?

MR. MCCARTIN: Yes. No colloids. Certainly absorption is a big part of the delay time for many of the regular barriers, yes.

DR. HORN: Okay. So it is just the colloidal transport that you didn't calculate?

MR. MCCARTIN: Correct.

DR. HORN: Do you have any idea how much that would contribute or --

MR. MCCARTIN: Off the top of my head, no. In previous years, we have worked at colloid transport, and felt that it was not a significant contributor, the issue being primarily that it is not so much the formation of colloids which certainly will exist, but the transport of colloids very great distances in significant quantities.

But that was a few years back, and we are continuing to follow what DOE is doing with respect to colloids.

DR. HORN: Right. Then would you expect to integrate that into your calculations eventually?

MR. MCCARTIN: Well, we have done calculations with colloids. These do not. I mean, we can certainly do that. The issue though is how far, and is there a filtration mechanism for colloids being filtered out along very long transport distances.

And that really is the issue, and I will say that we continue to look at that as colloids certainly are a process that certainly defeats some of the benefits of a soluability limit.

CHAIRMAN HORNBERGER: Thanks very much, Tim, and we look forward to continuing interactions. We now have to take a short break, a very short break, and the Los Angeles television people have learned that we have a very photogenic Jeff Ciocco doing the next presentation, and they need five minutes time to set up. So we will take a five minute break.

(Whereupon, at 11:22 a.m., the meeting was recessed and resumed at 11:32 a.m.)

CHAIRMAN HORNBERGER: Okay. The meeting is reconvened. Before we start, I would like to remind everyone that there is a sign-in sheet outside the door, and we would appreciate it if everyone would sign it so that we have a record.

Our next presentation is by Jeff Ciocco, and he is going to tell us something about the public comments received on the draft Yucca Mountain Review Plan. Jeff.

MR. CIOCCO: Yes. My name is Jeff Ciocco, and I am with the NRC staff. Thank you, Dr.

Hornberger, and committee members. We are pleased to come back and continue our interactions on the development of the Yucca Mountain Review Plan, and I say we, because Pat Mackin, from the Center from Nuclear Waste Regulatory Analysis, is going to join in on the presentation as we get into some of the specific comments. Next slide, please.

My agenda for the presentation this morning, we are going to go through a little bit of the background of the Yucca Mountain Review Plan development, and we will call that the YMRP. I am going to go through how we are categorizing the Yucca Mountain Review Plan comments, and the issues identified in the comment categories, and we will go through a path forward and summary, and conclusions. The next slide.

I have a slide that goes through the development of the Yucca Mountain Review Plan, which started in November of 1999, and we did an annotated outline, which I believe there was a brief presentation given to the ACNW at a public meeting back in Rockville, Maryland, in May of 2000.

We internally drafted the revision zero in July of 2000, and revision one was completed. In November of 2001, the NRC published the draft revision one and put it up on the website, and made it publicly available in our records system.

And then finally in March of 2002, draft revision two, which is the one out for public comment, and it is NEUREG number 1804, was published for public comment. On August 12th of this year, the public comment period ended.

Now what I don't have up there is our next steps, and just briefly we are putting the pen to the paper now if you will. We have gone through and we are reading the comments, and categorizing all the comments, and rereading the Yucca Mountain Review Plan, and rereading the regulations, and putting the pen to paper.

And it is an iterative process, and we are just in the midst of really kicking it off. We have got a team put together back at the NRC at headquarters, as well as the Center for Nuclear Waste Regulatory Analysis in San Antonio. The next slide, please.

A short chronology of the public comments on the Yucca Mountain Review Plan. This is the draft report for comment, revision two, and on March 29th of this year, we issued a Federal Register Notice for a 90 day public comment period, which is scheduled to end on June 27th.

I don't have a bullet, but I think it was back in April where Pat and myself presented the contents of the Yucca Mountain Review Plan to the ACNW back in Rockville, Maryland, on May 21st through the 23rd of this year.

We conducted three public meetings; one in Pahrump and two in Las Vegas, to go through the contents of the documents, and to solicit input. On June 4th of this year, the NRC and DOE conducted a publicly held technical exchange on the Yucca Mountain Review Plan to get some early feedback and discussion with the Department of Energy.

On June 21st of this year, we extended the public comment period by 25 days, and we issued a Federal Register notice for that. That was at the request of a public citizen.

On August 12th, the extended public comment period ended, and all of the public comments that we received are a matter of public record, and they can be viewed in our publicly available record system.

The next slide.

What I have here is a listing of the commenters. This is an alphabetical listing, and every organization on this page, and I call it -- this is an alphabetical listing of the organizations, and I think it is important to go through this so you can see that we really had a wide distribution for the Yucca Mountain Review Plan, and we received a lot of comments from a lot of organizations and private citizens.

So let's just walk down through it. There is 11 on this page, and we received the ACNW submitted comments, and the American Society for Mechanical Engineers; Citizens Alert from Las Vegas; Community Against Railroad Pollution from Oregon; CP&L; Global Resource Action Center for the Environment; the Moapa Band of Paiutes; the National Association of Regulatory Utility Commissioners; the Nevada Nuclear Waste Task Force; the Nuclear Energy Institute, which also had comments.

These comments were also endorsed by EPRI, and Next Lawn Generation recently sent a letter, and I think about a week or two ago, CP&L and Florida Power also endorsed the NEI's comments.

We received comments from the State of Nevada on August 9th, and I understand from Steve Frischman earlier today made a comment that they may be providing additional comments as well. I have not received those as of yet. Next slide, please.

We received comments from Nye County, from Public Citizen in Washington, D.C.; the Sierra Club, the Florida Chapter; Squarey Consultants from Las Vegas; the Timbisha Shoshone Tribe; the Tennessee Valley Authority, Nuclear Division; the U.S. Department of Energy, and the U.S. Environmental Protection Agency.

So there is approximately – and, oh, White Pine, Nevada. So there is approximately 20 commenters representing organizations. We received 23 comment packages from individuals, and the demographics on those really go across the country; from Eugene, Oregon; and from Nevada, Wisconsin, New York, Maryland, Florida, and Georgia, and other States.

And so we received a lot of comments, and we also have comments that we have had to extract from our May 2002 public meetings. As I said, there were three public meetings and we have meticulously gone through those to pull out public comments as well. The next slide.

With the comments received, and there were over 900, and probably closer to a thousand, we have gone through an effort of trying to categorize the public comments, and the first categorization is based on the organization of the review plan, and the next is on the structure, which is on my next slide, and which I will get to.

And this doesn't really apply any importance, per se, but it was a way of categorizing it and getting the comments so that the NRC staff could respond to them.

But the categories that are based on the Yucca Mountain Review Plan organization, we have gone through the comments really based on the chapter setup of the review plan; the introduction, Chapter 1, and acceptance review, and general information, and those are Chapters 1, 2, and 3.

And the following five bullets are all Chapter 4; preclosure, post-closure, research and development to resolve safety questions, and performance confirmation, and the administrative and programmatic areas. So that was our first categorization of comments. Next slide.

Then we have comments and what we have titled as additional categories. And these are really subjective, and we see as we go through, and as we write responses, you can move a comment from one bin to another, and so there is a lot of interaction, and a lot of iteration that has to go through those, and one comment doesn't necessarily fit in one category.

And as I look through the room here, I see a lot of the commenters out there, and I am sure that you can understand that. So the additional categories, we have categorized to the structure of the review plan, and that is more focused on the -- there is comments on the organization, and how the YMRP is laid out, and comments like the review plan shall look more like a reactor safety analysis report.

And comments about the redundancies and comments about the glossary of the review plan. We have another subcategory called selected topics, and in this one we have ones like a comment that we should include an example of a review process, and that is familiar to the ACNW.

And we have comments that we should explain inspection versus licensing, and I am going to go into some of these in more detail. And then we have an area called other comments.

Quantity-wise, we have received an awful lot in this area, and comments like we need to clarify the issue resolution process, and the environmental impact statement, and we received a lot of comments at the public meeting, as well as written comments on the environmental impact statement and transportation.

And a lot of comments, or maybe the most comments that we received, were around the transportation issue. My next bullet says that there were more than 900 very thoughtful comments, and probably closer to a thousand, including as we extract comments from the transcripts.

And as I said, the issues have been identified within each comment category. So with that, I am going to introduce Pat Mackin, from the Center for Nuclear Waste Regulatory Analysis, and you can go to the next slide, please.

And he is going to go through and start with the introduction, and go through how we have categorized and what some of the comments are in those areas. Okay. Pat.

MR. MACKIN: Thank you, Jeff. Good morning, members of the committee. The first area that we binned the comments into was the introduction, because the YMRP has an introduction, wherein we have defined general background material that is relevant to the staff in conducting its licensing review.

We had several comments in that area that required that we consider providing clarification to what has been written in the introduction. The first one that I mentioned up here is the definition of what risk informed and performance-based means.

Judging from the comments that we received, not only is that not clearly stated enough, but some people misunderstand what the Commission's intention is in implementing risk informed performance based regulation.

Another set of comments suggested that figures or graphics could be used to help clarify the licensing process, and the licensing review itself.

And finally there are a number of comments about how the staff intends to go about the licensing review. These reflected in some cases misunderstandings or disagreements with the licensing process.

For example, the YMRP introduction states that the plan is to be used with flexibility. Some commenters interpreted that as meaning the staff intended to be -- to compromise the principles in the regulation.

There were also questions about the staff's statement in the introduction that some analyses would be limited in conducting the licensing review.

So as we are examining those comments, we are looking for how we can either clarify or respond to those specific comments. Next slide, please.

Chapter 2 of the Yucca Mountain Review Plan addresses the acceptance review. An acceptance review is a comment step in the NRC licensing process, and there is obviously a great deal of confusion about what it means based on the number of comments that we got on the acceptance review.

And so we will be looking and responding to those comments as to whether we need to clarify the language in that section of the Yucca Mountain Review Plan.

In some people's mind, it appears that the term, acceptance review, means that the license itself is satisfactory, rather than just a determination by the NRC that there was enough information to proceed with the review, and to make a decision one way or the other.

An important comment that we see from more than one person was that there needs to be the flexibility to have more than one round of requests for additional information in the licensing review.

In writing the Yucca Mountain Review Plan, and then conducting the prelicensing consultation, it is a goal of the commission that there need be only one round of requests for additional information. But it is not a restriction. It is just a goal, and we need to clarify that.

There were several comments about the concept of a phrased or stepped licensing process, and the comments went both ways; whether the Yucca Mountain Review Plan allowed for such a process, and specified in enough detail, or whether it in fact did not allow for such a process. So once again there is a need for some clarification.

And lastly with respect to the acceptance review, since it is called an acceptance review, there were questions concerning what are the criteria for rejection since it is an acceptance review.

And I might note as we are talking about these things that these have been summarized from the 900 comments and it is not our intention this morning to propose to you how we might respond to individual or groups of comments, but just rather to give you an idea of the scope. Next slide, please. Thank you.

There is a section of the review plan that discusses general information and submission of general information as required by 10 CFR Part 63. We had a number of comments on that section, and one of the most important was relating to physical protection, and the NRC is reexamining physical protection as a result of the events of September 11^{th}, 2001, and it is likely that the results of that examination will appear and be incorporated into the Yucca Mountain Review Plan.

One commenter also noted and felt that the material control and accounting program was too detailed for a repository. The concept being that once waste was placed in a repository, that is where it stayed, and there is no real reason to keep close track of it after that.

And also the idea that inventorying and measuring might expose workers to more radiation than appropriate. So we are considering those comments as we go along.

And another one, and probably the largest one in this area, was in the discussion of information related to site characterizations. Some commenters felt that the Yucca Mountain Review Plan was asking for too much in this area.

And that it ought to be left to the more technical parts of the review plan later on, and that created redundancies the way it is written now. Next slide, please.

One of the major portions of the review plan of course is the section dealing with pre-closure performance, and we received a number of comments there. Possibly the most important one is the suggestion that we change the basic structure of the Yucca Mountain Review Plan, and that relates to, if you will, a comparison with the way that license applications were prepared for power reactors.

And where systems were described, and the design of systems were described individually, and then that supported the subsequent demonstration of safety.

The staff, in writing the Yucca Mountain Review Plan, focused on the performance objectives for the pre-closure period, which are radiation exposure limits, and upon the technique of pre-closure safety analysis, which is specified by the regulation.

And so this portion of the review plan is based on how one would conduct or then review a pre-closure safety analysis, starting with having the identification, and looking at events, and sequences of events, and looking at consequences, and looking at the likelihoods.

So it is structured along those steps, rather than on a systems based approach. So probably the most important comment that we received on pre-closure deals with that basic difference in approach to structure.

There are comments that we are not consistent with 10 CFR Part 63, and that is largely due to the fact that we have paraphrased wording in the regulation at various places, and the commenters have suggested that we not do that, and that we just use the language precisely from the regulation.

We have some people who believe that the preclosure portion is too prescriptive, and some who believe that it is not prescriptive enough. So we need to examine that again as we respond to public comments.

I will note that both for the preclosure and for the post-closure sections in developing the review plan, we received quite specific guidance from the Commission on the level of detail appropriate for a risk-informed performance-based regulatory program.

Some commenters noted that usually license applications have a separate section devoted specifically to how the facility might be designed to keep radiation exposures as low as is reasonably achievable.

In the Yucca Mountain Review Plan, we have structured that as an outgrowth of the preclosure safety analysis. So this is very similar to the first sub-bullet on this page.

And finally some people felt that we had put too much detail with respect to retrievability and alternate storage, and some people felt that we had put not enough detail. So again we have to reexamine those questions. The next viewgraph, please.

In the post-closure period, again a major comment dealt with the basic structure of the Yucca Mountain Review Plan, and I will just explain that quickly. The Department of Energy, in its assessment of performance, has nine principal factors at this point.

The NRC uses 14 model extractions, and so the basic question is how do you mesh these different approaches to assessing performance, and we will be examining that as we respond to the comments.

There are other similar comments that we should not have paraphrased the language from 10 CFR Part 63, but should have used it as exactly as it is written.

Multiple barriers received a number of questions, and Tim McCartin gave a thorough discussion of where the staff stands on multiple barriers at this point, and that will be considered as we move forward.

A number of commenters mentioned how

probabilities are assessed in the Yucca Mountain Review Plan, and that really relates back to how they are addressed in the regulations.

And so we need to make sure that we are in fact consistent with the EPA standards and with 10 CFR Part 63 as we finalize the review plan. One that I wanted to mention as well was the request for more than one commenter that we streamline the review plan in the model extraction areas.

The committee has looked at the review plan, and you are aware that the section that deals with the 14 model abstractions is quite long, and it repeats five generic acceptance criteria for each of the model extractions.

The basic comment here is that we ought to list the five generic acceptance criteria once, and then use them 14 times, rather than repeat them 14 times and expand the size of the Yucca Mountain Review Plan.

And what we were wrestling with here as we respond to these comments is whether the information presented in the Yucca Mountain Review Plan relative to each of the 14 model extractions is different enough that it ought to be retained separately in its own section in the review plan.

And finally with respect to post-closure, there were questions as to whether we had adequately understood or interpreted the EPA standards with respect to individual protection, ground water protection, and human intrusion. And so we will give that close consideration as we refine the review plan. Next slide, please.

I will go over this one quite quickly. The issues with respect to the research and development program to resolve safety questions, and with respect to performance confirmation were similar, which are how are those two aspects of a licensing review different, and to make sure that in the Yucca Mountain Review Plan that we don't confuse them, and allow performance conformation to substitute for research and development programs, or vice-versa. The next viewgraph, please.

In the administrative and programmatic areas of the plan, we received a large number of comments on the quality assurance sections that basically address whether there are requirements, or the guidance as laid out in the Yucca Mountain Review Plan is up to date, and whether it is consistent with other QA program guidance.

So again we will take a close look at that as we move forward. Some commenters noted that we ought to remove the expert elicitation section. The approach that we took in writing the Yucca Mountain Review Plan was that since expert elicitation information as required by the regulation, we provided a place in the review plan where a reviewer could go and understand what the requirements for a successful expert elicitation are.

Commenters suggested that we not do that and just examine expert elicitations as they are presented in the license application. So we will be examining those issues as we refine the plan.

The final three areas there, again, deal with questions on both sides of whether we have been too detailed or not detailed enough in these areas, and so we will examine that as we respond to the public comments.

At this point, I will turn the presentation back to Jeff, who will cover the last few review plan areas and wrap it up.

MR. CIOCCO: Thank you, Pat. Jeff Ciocco with the NRC staff. On slide 16, we are getting into the category now where we have labeled it as the review plan structure. At first, we received a lot of comments regarding the organization of the review plan to look more like a reactor review plan, particularly in the preclosure areas.

And what you are going to hear me talk about now, there is a little bit of redundancy from what Pat categorized earlier in his comments, that it fit nicely into the structure of the organization of the review plan.

This is mainly in the preclosure area, where commenters suggested that we break out structure systems and components first before we go into the preclosure safety analysis, and that we incorporate the phase licensing flexibility more into each particular section, and have an acceptance criteria and a review method to clearly explain what is required for a construction authorization.

And which criteria apply, and which criteria would apply for a license to receive and possess spent nuclear fuel and high level waste. We received comments that we needed to correct the mismatch with the expected DOE license application, and this really gets to the heart of Part 63.21, which requires general information, which is in Chapter 3 of the review plan, and Chapter 4 is the safety analysis report for the preclosure and post-closure, and the administrative and programmatic sections.

There was a request from several commenters that we describe and clarify how we match the model extractions to the key technical issue structure. We heard some discussion of this earlier when Jim Andersen was giving his presentation, and how we were going to move fro the KTI structure over to the model extraction areas.

Once again, as you heard Pat mention several times, we received several general comments that there is too much detail, and that in a risk-informed performance stage review plan that you don't need to provide as much prescriptive detail.

And on the other hand, we heard from some organizations that there is not nearly enough detail in order for the NRC to do its licensing review in several areas, particularly in the post-closure area.

We also heard that we need to improve the consistency with 10 CFR Part 63. One example is that Part 63 talks about reasonable expectation, and reasonable assurance. We also have the term in safety occasion in the Yucca Mountain Review Plan, and which we need to get back and reevaluate.

There was comments regarding the physical protection plan, and that we need to be consistent with the Part 63 which talks about actually submitting a plan, and the Yucca Mountain Review Plan talks about a commitment to a plan, not only for the physical protection and the material and accounting program. Next slide, please.

Continuing on in the review plan structure. We were asked and comments were that we remove the redundancy, and this is the repetition of the acceptance criteria and the review methods in each particular section.

That we remove the inconsistent and out of date codes and standards, and there were several organizations that felt that we had several nuclear reactor reg guides, and codes, and standards, that were not applicable to Yucca Mountain.

Several comments were editorial improvements to the plan, and more than one organization asked that we improve the glossary, and provide two or three added -- probably 200 or 300 words that they would like to see, as well as clarifications.

Next we are getting into an area that we have called selected topics to address confusion on the licensing process, and Pat touched on some of this, which really refers back to Chapter 1; when does the clock start on the NRC review.

Is it when a license application is received, or is it after the acceptance review, or is it after the Federal Register notice of hearing. And a lot of this was addressed in Chapter 1, and I think we need to get back and look at the clarification of that.

And we also talked in Chapter 1 about finishing a review according the Nuclear Waste Policy Act in three years so that people will know what are the consequences if we don't finish that review.

Several commenters asked that we use consistent terminology, and one that we have already talked about is reasonable assurance versus reasonable expectation.

Reasonable assurance is in the preclosure area and reasonable expectation is used in the post-closure area. We need to get back and look at the clarification.

And conservative or bounding analyses, and some commenters felt that we interchanged and didn't correct use spent nuclear fuel versus high-level waste, terms defined in the Nuclear Waste Policy Act.

Getting back to the safety case, waste isolation, and important to performance, and reasonable assurance, and reasonable expectations.

And there was also comments concerning license condition versus license specification, which is required in Part 63.21. The next slide, please.

It was requested that we clarify the purpose of inspection versus licensing, and what is the NRC's role after a licensing decision is made, and what are the penalties for violating licensing conditions, and what is the financial compensation.

And most of these were referred to and there is a figure up in Chapter 1, which showed the level of detail required for a licensing decision, versus inspection.

There was a request that we provide an example of the review process, and that was talked about in the post-closure, and that we clarify the requirements for data transparency and data traceability.

The next slide, on page 20, we have these categorized in an area called other comments. Several commenters asked that we clarify the issue resolution process. There was not a lot of explanation in chapter one on this, and there was some confusion about the 293 open items that Jim Andersen, or actually that is 293 agreements that Jim Andersen talked about this morning, and how does that plan into the Yucca Mountain Review Plan, and what is the role of the prelicensing process, which we are in right now, and an evaluation of that area with the Yucca Mountain Review Plan.

A lot of comments, and we received these publicly, or verbally at the public comment, or at the public meetings that we explained the NRC review and adoption of the Yucca Mountain Review Plan.

There is a brief explanation in Chapter 1 that the environmental impact statement would accompany any license application, but we didn't go into very much detail into the review and adoption process. This was focused on the safety review of the site.

There were a lot of comments from several organizations and private citizens regarding transportation issues, and rail issues, and truck issues, across the country.

There was a request that we allow greater participation in every stage of licensing from the time that the license application is received, and we had comments that the public be involved in the acceptance review at different points, critical points in the acceptance review, et cetera.

A few comments were received regarding

project financing, and how can we be assured that the DOE would receive an adequate budget, and what is the NRC budget, and will there be adequate staffing for the NRC to conduct its licensing review and inspections.

And what is the financial liability if there is a leak from the site, and there was reference to the super fund monies, and who would actually pay for any clean up.

The next slide on page 21, and this is still under other comments, and that we answer concerns related to 10 CFR Part 63. Some organizations felt that we had carried over frailty in Part 63 somewhat erroneously into the Yucca Mountain Review Plan.

There were comments received that the performance objectives laid out in the 10 CFR Part 63 were not protective of the human health and the environment.

There were comments received that the 10,000-year regulatory period is not sufficient to protect the public health and safety.

And commenters suggested that the lack of sub-system requirements in Part 63 shouldn't be carried over into the Yucca Mountain Review Plan, and that is a reference back to Part 60, 10 CFR Part 60.

We received comments that we need to address the concerns of the frailties of 10 CFR Part 963, as well as EPA standards at 40 CFR Part 197. We received comments that we needed to clarify the compliance with other statutes, regulations, and treaties.

And there was references to the Resource Conservation Recovery Act, the Super Fund Act, and a few other regulations and treaties, such as the Ruby Valley Treaty, and land ownership.

There were comments on what would the NRC do if the DOE license application is late, and this was 90 days after the site designation by the President, and what amounts or weights can be stored at the proposed repository.

And we received a lot of comments about the lawfulness of the retrievable storage facility at Yucca Mountain. Carrying on, we received a lot of comments that fell into the other comments areas. On Slide 22, that the NRC needs to consider alternatives to geological disposal, and on-site disposal.

That the NRC needs to consider alternatives to Yucca Mountain, and these were people strongly opposed to the Yucca Mountain Review Plan, and to the Yucca Mountain projection.

There were a lot of comments received on the site selection process and people that disagreed with that process, and that we need to consider alternative siting criteria, such as back in 10 CFR Part 60, and DOE's 10 CFR Part 963.

And that we need to clarify the requirements for land ownership, regarding the Western Shoshone Tribe, I believe. And we need to clarify requirements in the form of a license application, and this really has to do with what is required under 10 CFR Part 2, Subpart J, regarding electronic media versus paper copies of a license application.

Several commenters asked that we clarify the rules of the participants between the NRC, DOE, EPA, and other agencies, the Center in San Antonio, and other contractors, and the public.

And this is my last slide for the other comments, and we received several comments on the use and disapproval on the use of nuclear energy. We received a lot of comments in a lot of technical areas, where they really focus on areas where it is DOE's responsibility and what they need to provide a license application.

As far as the documents and analysis, and design issues, and technical issues, such as ground water flow, when would the first waste package fail, and is there a potential to contaminate other areas, such as the Nevada Test Site.

And we received comments regarding what the commenter felt was the poor past performance record of the U.S. Department of Energy, and how would the NRC consider that in its licensing review.

And one commenter in particular felt that there was a conflict of interest with the NRC in regulating nuclear power, as well as nuclear disposal.

So with that is my last slide, Slide 24, and I am going to go through our path forward and where we are at now. We are in the process of responding to the public comments received, and we are preparing a comment summary document.

And as appropriate, we will revise the Yucca Mountain Review Plan in response to these comments, and submit that document to the NRC's commission for approval. And then we will publish the final Yucca Mountain Review Plan, Revision 2, next year.

And in summary that is it. We are putting the pen to the paper now, and we are going through the comments, and reading, and rereading comments, the regulations, the review plan.

CHAIRMAN HORNBERGER: And when do you expect to have a response, and when do you think you might have Revision 2 for Commission approval?

MR. CIOCCO: We are -- a lot of these dates, we are not really certain at this point. We are going through the process of evaluating all of the comments. It is a very complex technical document, with a lot of thoughtful public comments submitted.

But we expect to submit the Revision 2 to the Commission say the first part of next year sometime, and then after it goes through the Commission review and approval cycle, we would then issue it out with a Federal Register notice, which would have our response to comments, as well as the final Revision 2.

CHAIRMAN HORNBERGER: Raymond.

VICE CHAIRMAN WYMER: As you pointed out there were a great many comments, and I suppose all levels of sophistication and not so sophisticated. There was a great deal of passion from some of the commenters, I'm sure.

MR. CIOCCO: Yes, sir.

VICE CHAIRMAN WYMER: And I think there may be a perception among some of these more passionate people that these comments go into the NRC and they sort of disappear for a while.

And then the final YMRP will come out, and comments may or may not have been addressed. It would probably be helpful and maybe of some consolation to some of these people, that if you went into a little more detail describing what the process is of deciding which of the comments to incorporate.

And what final approval process there is, and what sort of checks and balances there are on the process.

MR. CIOCCO: That is well said, and we are right now reviewing and responding to the comments. It sounds like the heart of your question is what comments will the staff accept, and what comments will the staff reject.

VICE CHAIRMAN WYMER: The question is what is the process and what are the checks and balances.

MR. CIOCCO: Well, at the staff level now, and that is at the non-managerial level, the staff is preparing the responses. And these are all the individuals, as well as the subject matter experts, who wrote the Yucca Mountain Review Plan, are taking those comments, and reading, and rereading the regulation and the review plan, and the comments, and making a staff decision on whether we accept or reject that or any part of a comment.

And from that, we will take the comments and put them forward to management, and we will show them our responses in a summary, and try to go through some prioritization for the management to show maybe which are the more important comments.

Clearly, some of these we can answer that really aren't very contentious, and the ones that we need a management decision, they will be put forward to the management, and then the next level of management, we would submit the entire package and get response to comments.

And there is also a legal review in there as well, and that we would submit the final package to the commission for their review and approval for the final Revision-2.

DR. GARRICK: Of course, the real issues are in the details, and I am not too anxious to hear about a thousand comments at this point. But the one part of this whole process that is new and different is the post-closure period.

And I would like to hear just a brief comment or two of the thrust, if you wish, of the comments in 2 or 3 categories. One was the change criteria for demonstration of multiple barriers, and what seemed to be your current interpretation of the principal message there.

And the same thing with respect to the clarification of the different standards, the individual protection standards, and ground water standards, and the human intrusion.

What seems to be the principal messages, and we won't hold you to them, but that came through on those two categories of comments?

MR. CIOCCO: Okay. I think I can answer the second, first, regarding the individual protection standard, and the ground water protection standard, and the human intrusion standard.

We received comments from I know at least two organizations, and one organization felt that we did not apply correctly the representative volume, the calculation of the representative volume, between the individual protection and the ground water protection standard.

It had to do with the 3,000 acre feet of water that represented a volume. And regarding the human intrusion, there was an incorrect application. I have a thousand of these running around in my head, and so I am trying to recall what that particular issue was.

Regarding human intrusion, I believe it was a comment regarding the scenario where when you are drilling into the waste package, and where we were specifying a scenario where the drill rig hit the waste package, versus what is specified in the regulation, or something to that effect.

Now, what was your other -- it was on the multiple barriers?

DR. GARRICK: Yes, on the multiple barriers, and I am particularly curious about whether or not the thrust of the comments was how we are going to reach decisions on the barriers, et cetera, et cetera.

MR. CIOCCO: I will let Pat join in here.

MR. MACKIN: Pat Mackin from the Center for Nuclear Waste Regulatory Analysis. The main comment there was whether in fact the reliance was going to be entirely on engineered barriers, rather than both engineered and natural barriers.

DR. GARRICK: Well, part of what I was getting at was one of the major changes from Part 63 from other earlier regulations had to do with subsystem requirements.

And I was curious as to whether the whole issue of subsystem requirements had resurfaced in the context of comments on that.

MR. CIOCCO: Oh, yes, it certainly did. It did and there was an organization that felt that we should reflect – that the Yucca Mountain Review Plan should reflect the 10 CFR Part 60, the subsystem requirements.

And they pointed out the frailties I believe they said in 10 CFR Part 63. Absolutely. As well as Part 960 of DOE's regulations.

DR. GARRICK: Thank you.

MR. CIOCCO: You're welcome.

CHAIRMAN HORNBERGER: Mike. Staff?

DR. LARKINS: The other night we heard from some stakeholders at a meeting in Nye County dealing with commitments. I don't know if that was an issue, but this is really more towards a commitment from DOE on emergency planning and security, and licensing changes. So at some point we probably would have had those comments to you.

MR. CIOCCO: Okay. Thank you. We did receive comments, and one commenter talked about what they felt were inappropriate interactions between DOE and the NRC, and commitments that were being made, or were not in the public forum.

There were public comments received from one of the counties on emergency planning assistance, and they were probably the largest commenter regarding emergency planning.

DR. LARKINS: This dealt with the requirements for emergency planning in place and --

MR. CIOCCO: Right. Okay. Thank you. And, yes, we did receive comments that the Yucca Mountain Review Plan doesn't reflect emergency planning, along with transportation.

And the Yucca Mountain Review Plan is written for the safety evaluation of the site, of the Yucca Mountain site in Nevada, and several commenters pointed out that we need to reflect that the emergency planning needs to reflect emergency planning from the reactor sites, and from the current storage areas to the Yucca Mountain site as well.

MR. MACKIN: Pat Mackin again from the Center for Nuclear Waste Regulatory Analyses. There was another commitment related category of comments that we got, which was related to the staged licensing questions that we got, which was whether there were things that could be presented only as commitments at the stage of a construction authorization, and that might not be actual plans and programs at the time of a license to receive and possess. So that is another aspect of commitment that came out.

MR. CIOCCO: Particularly in the physical, and I think I mentioned this, but in the physical protection area, and the NCNA commitment, versus the plan.

CHAIRMAN HORNBERGER: Okay. Other comments or questions? Does anyone have a comment? Judy.

MS. TREICHEL: Judy Treichel, Nevada Nuclear Waste Task Force. This is an area where I am very, very familiar with, and this is extremely important to the public, and as you mentioned there were a lot of commenters, and you received a lot of passionate comments on this.

And one of the things that troubled me this morning is some of the presentations talking about compliance with the draft, and using that draft when you know that you have gotten a lot of very strong comments, both for and against the review plan, but especially against.

And we saw this in Part 63 as well, where we spent at least a year listening to presentations where DOE was in compliance with a draft Part 63. We had not seen a final, and I don't know if there was a final.

But when it came out, it was very much like the draft, and it almost had to be, because so much had been mailed to that draft, and it seems to me that before charging ahead and showing compliance with this draft, that the NRC, the staff, whoever it is, takes the time to do the interactions to really show people who take their time, which is not paid for.

I do this for a living, and so do many of the other organizations that you listed as having received comments from. But there is a lot of people who come home from work, and put the kids to bed, and turn off the t.v., and start reading these documents, and taking their time to do this stuff.

And they really deserve your respect, and it should be taken into consideration. And I don't think that your big job is to clarify or respond to. Your big job is to make this review plan reflect what people expect, because the bottom line is that this is really the only place the public actually plays a role in licensing.

And licensing hearing is very public unfriendly, and it just plain is, whether it is a reactor or any other site. It's just not built for public interaction, and this one may be even worse with the electronic courtroom.

We have no idea what we are expecting, and most people can't pay to play. So this is it, and this is the place where people are going to have any say at all, and I think you need to respect that.

MR. CIOCCO: Okay. Thank you. Judy, maybe you could explain. You said that before showing compliance, and I am not sure what you are -- we are not showing -- did you mean compliance with the regulations, or if you could just clarify for me what you meant. Early on, you said before showing compliance.

MS. TREISCHEL: Yes. In a couple of Jim Andersen's presentations, he talked about –- let's see. I am trying to find where it was.

CHAIRMAN HORNBERGER: Jim was basically talking about having the integrated IRSR reflect the civil --

MS. TREICHEL: Yes, moving toward either going to the review plan, or showing the way they are going to blend what they are doing now with the review plan, and just using the draft in order to do that.

And we would hope that that review plan would change a lot, and so comply with the final that reflects all of these things that you are receiving.

MR. CIOCCO: Okay. Thank you.

CHAIRMAN HORNBERGER: I just want to follow up on that comment. Compliance is one of those words that can be used several different ways, and just to clarify that when we were talking about having the IRSR comply with the draft Yucca Mountain Review Plan, it just meant not in parallel. There is no regulatory issue involved here.

It is really just having things go forward in parallel. Other comments? Thank you very much, Jeff.

MR. CIOCCO: You're welcome.

CHAIRMAN HORNBERGER: We look forward to hearing how you resolve these issues, and how you present your responses to comments, and moving forward to a final Yucca Mountain Review Plan.

MR. CIOCCO: Thank you.

CHAIRMAN HORNBERGER: Okay. I think we are at a point in our agenda where it says lunch, and so we will break and reconvene at 1:30.

(Whereupon, at 12:21 p.m., the meeting was recessed.)

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

(1:31 p.m.)

CHAIRMAN HORNBERGER: Good afternoon. The meeting will come to order. This afternoon, we are graced with the presence of one of the ACNW's own staff making a presentation.

Mike Lee is going to tell us about well drilling in the Amargosa Desert Area, and that is our first presentation for this afternoon. Mike.

MR. LEE: Thank you, Dr. Hornberger. On the first slide there, I would like to just acknowledge other staff that have contributed to this work, and the work that I am going to actually be talking about was conducted prior to my arrival at the ACNW.

But for the record, I would like to note that I am very happy to be with the ACNW. Next slide, please. Okay. Over the years, as you all know, the NRC has served a variety of functions in the high level waste program, foremost of which was to develop a regulatory framework, both in the generic, as well as in the site specific sense.

And also to prepare for potential DOE license applications, and so it was necessary to develop an independent review capability, and frequently we hear a lot about development capability in the context of performance assessment work.

Consequently, the staff found that it needed to be knowledgeable on water use issues, and because of the uniqueness of the program, we found that there was no single source of information, but rather multiple sources of information.

And as the staff began to review information in the literature, we found that there was both printed, as well as electronic media. The typical data source or information source might be some scientific journal, or book, and then there is also databases, which with the increase in the use of computers are becoming more available. Next slide, please.

And as Tim noted earlier, when he talked a little bit about his thought piece for multiple barrier analysis, over the years the staff has required a lot of knowledge and experience, but they don't necessarily commit that to paper.

And so having a lot of our work behind us, in terms of the development of regulations and guidance, and acknowledging that there is still work to be done in some respects.

And we thought it might be useful at this point in time to begin to kind of just document what our state of knowledge is with respect to water use issues.

So what we went about doing was just kind of reviewing the literature or kind of collecting the literature that we had already reviewed, and document what we understood the history of water development to be in the Amargosa Valley area.

And so we examined the literature covering the period from about the late 1800s to 1990, and what we attempted to do was not only describe what the history of water development was, but also provide a little information regarding what that pattern of development might be.

So we looked at not only the Jackass Flats area, which is Area 25 of the NTS, but also the Amargosa Valley area, Crater Flat, and we also discussed a little bit about the development of a water system within the Nevada Test Site in general. Next slide, please.

And as I noted earlier the information sources that we relied on, in terms of printed media, were engineering and geologic reports that have been published over the years.

For example, USGS professional papers, and the State of Nevada water resource investigations. We also looked at historical treatises, such as those published by Richard Lingenfelder, who has written a history of the Amargosa Valley and Death Valley.

And Margaret Long has written, "Shadow of the Arrow" which talks a little bit about the Amargosa, and surprisingly some information that you can find in any water development.

We also looked at archeological investigations, such as those published by Morman for NTS about 1969, as well as a number of the investigations that have been published by the Desert Research Institute.

And we also looked at some anthological studies. For example, Julian Stewart published in 1935 a reconnaissance and census of Native Americans in Southwest or Southern Nevada, and that was also a useful source of information.

And we also relied on some electronic sources of information, such as the State of Nevada well-drilling database that is maintained by the State Engineer's Office up in Carson City, which is now available on the internet.

As well as the USGS database on well-drilling activity nationally, and it is indexed by

State. Next slide, please. Oh, I'm sorry, one of the limitations to this literature is that because of pressing priorities we could not necessarily review all of the literature that is publicly available.

As well as we can't account for drilling records that were not afforded in these databases, and the other issue, of course, is that any time you look at data in general there is always the issue of inconsistent or incomplete data. Next slide, please.

So, in summary, the fact is that we found that have affected water use in the history of the Amargosa Desert area is the adoption of growing technology was an important development in the ability to exploit the underwater resource, and certainly there was the evolution of pump technology was a contributing factor.

The introduction of electronic infrastructure in the Amargosa area was an important issue as well. Electricity was introduced about 1962, and as I will show later on in some of the slides, and you can see spikes and well drilling activity as a result of the introduction of electricity.

Another important area, of course, is the growth of geologic knowledge. A lot of the early water exploration was far from scientific in many respects, and it was kind of based on the pattern of drilling that was first established in the Las Vegas Basin by a number of the railroads at the turn of the century.

Land use practices for policies, rather, were also instrumental in helping to exploit the water resource, such as the homesteading movement, and last, but not least, soil conditions, particularly as they relate to the potential farming, appears to have been a factor as well.

Some specific milestones that we can look at, in terms of how the water use has kind of evolved over time, we have a model of the Native American farming that was present in the Ashe Meadows area, as well as up in the Canes Springs area, and BS in the early 1800s.

Mining certainly made a contribution to the ability to exploit the water resources, principally from springs, but nevertheless that was a factor.

Introduction of railroads, in particular the T&T Railroad running from Ludlow, California, up to Beatty, at the turn of the century, was an important development, because railroads had access to technology, as well as capital.

So in terms of the ability to exploit the water resource, they were the first to bring in some drill rigs, and take advantage of what was thought to be water underground.

And certainly in terms of farming activity, the T&T experimental range, which was established to the east of Lehman Mining District over there in the Funeral Mountains was another major development.

And last, but not least, of course is homesteading and desert reclamation, which took place in the late 1800s, and then again in the 1950s, shortly before the development of the test site.

What we found in our review of the literature is that approximately 985 wells have been dug or drilled, and those wells were first introduced in the late 1800s, and Amargosa, in the southern regions of the Amargosa Valley around the State border or State line of California and Nevada.

And the Franklin I think was the first one drilled or dug in 1852. Drilled waters, and I have already made reference to 1906, and those were associated with the railroads, and sustained the link up until now from the late 1950s.

But when you talk about drilling, there is many ways to describe it. You can certainly talk about the frequency of drilling, and the amount of drilling, or the density of drilling, and this is one of the classic problems in reviewing data is how to describe the data that you find.

So if you took to the next slide, if you look at the distribution of drilling frequency by end use, this is just looking at the data that has been published electronically, and how many wells were drilled, and who can come up with a distribution that looks something like this. And I think that everyone should have a copy of this in front of them, but you can see that the first spike and drilling activity noticeably was in about 1955 to '59, and we reviewed the data over a five year period just for the ease and analysis, and you can see that most of the drilling at the time was historically in the context of the irrigation or sod drilling.

And this first spike we believe is associated with the knowledge that there was movement underway to get electricity into the valley, and you can see certainly in the time period from '60 to '64 that there was a significant amount of drilling, and this corresponds pretty good with what we believe was the reported use of electricity being introduced in the valley for the very first time.

The other thing that this graphic displays is that there has also been a change in the trend of drilling. You can see that over time there has been a reduction in the amount of drilling for irrigation and stock use, and an increase in drilling for the purposes of domestic -- providing domestic water supply, as well as an increase if you will in the amount of drilling classified as test and monitoring.

So if you turn to the next slide, just as a little summary, you can see that if you look at the Amargosa Hydrographic area, and this is the geographic area that we are probably most familiar with, and it is basically referred to as the Amargosa Valley.

About 964 holes were reported and again most were drilled or if look at the time period before 1999, which we have already talked about, but if you look at the trait of the hydropathic area, we report 24 or we identify 24 bored holes in the literature drilled from the 1981 to '99 time frame.

Jackass Flats, which is Area 25 within NTS, initially we identified 185 bore holes which were reported in the SEP, and then most recently in the site recommendation to the President, and DOE acknowledged that it was approximately 454 holes that have been drilled through 2001.

And based on that review of the literature it appears that most of the bore holes initially were drilled in the '53 to '86 period, and just as a matter of information, when you look at the water supply system within NTS, historically NTS has relied on 17 wells for its water supply, and most were drilled in the 1950 to '64 time frame.

To just kind of wrap up the frequency data, most of the water drilling has taken place for the purposes of providing fresh water supply, and about 43 percent of the wells drilled do that, and 27 percent for agricultural purposes, and 19 percent for scientific applications, and 9 were reported as unused or unspecified.

And one of the conclusions that can be reached in looking at the data on frequency of drilling is that 45 percent of the drilling has been conducted over the last 45 years, with the greatest period of drilling was in the '60 to '64 time frame, accounting for about 17 percent of all drilling, and 44 percent of the drilling has been for agricultural use.

Another statistic that you can look at is the amount of drilling. If you were to drill a bore hole, how many feet were drilled, and this provides a slightly different perspective on the nature of drilling.

And as you can see here again, test and monitoring occur initially in the time periods that we have already talked about a little bit, but in terms of overall drilling, it appears that drilling for test and monitoring purposes appears to dominate this particular drilling statistic. So if we could turn to the next slide.

This provides a summary of those statistics, and 43 percent of the drilling by amount is for scientific applications, and the literature, specifically, we relied on the State of Nevada well drilling classification system, which refers to wells as either test or monitoring wells.

Medium depth for test wells was about 400 feet, as opposed to monitoring wells at about 215 feet. Agricultural wells, which account for 25 percent of all drilling amount, had a medium depth of about 300 feet; whereas, stock wells had 513 feet.

Fresh water supply wells or domestic wells, had a median depth of about 181 feet. And one of the conclusions is that you could establish based on a review of these statistics is that about 45 percent of all the drilling has been undertaken under the last 20 years.

Another way to characterize drilling activity was to look at the density of drilling, and physically where has all the drilling been concentrated, and in this particular aspect of the literature review, we focused primarily on the State of Nevada and USGS databases.

And we limited our description of physical drilling to those areas that I talked about earlier, the Jackass Flats area, and Amargosa Valley, and hydrographic areas in Crater Flat.

And what we thought we might do to kind of portray this information is to adopt an analysis technique that was developed by a mineral economist at Penn State University by the name of John Griffis, and he introduced this concept of unit regional value analysis technique.

And what Professor Griffis was interested in doing is for the purposes of mineral exploration trying to compare different areas geologically and geographically with some kind of standard metric, and without getting into the analysis technique, he wound up -- he would be interested, for example, in the amount of gold produced in a square mile.

And so you could typically go back through the literature and identify that information, and locate physically where the mine was located, and then develop a geological index to kind of say that this is kind of an index if you will for what type of economic activity potential might exist at this particular location.

And then comparing areas of similar geology, you could begin to make some inferences from a mineral resource exploration technique. We didn't go that far. We tried to keep it a little more simpler by just looking at the density of the frequency statistics by section within the township range coordinate system.

So if we go to the next slide, what you see here is the number of bore holes drilled per section, and you get a distribution that looks something like this, and I regret though that we were not able to update this based on the new one.

We have some additional wells for Area 25, as well as the Crater Flat area. But generally you can see that up until 1999 that much of the drilling had been concentrated in the Amargosa farms area, which most of us are pretty familiar with.

There is a lot of agricultural activity, as well as homesteading that has historically taken place down there. And so this is the distribution that you get. That little red dot, if you can look in your mind's eye, if you are familiar with the 95 area, you can see a little red dot up there.

That corresponds to the Beatty level waste site, and so that has also been a site for a lot of drilling activity historically. The next slide just provides a little summary of what the drilling density looks like when you talk about concentration of drilling.

And that is pretty self-explanatory, except for the purposes of time, I will just move along. You can get –- on the next slide, you can also use the data as they come up with some simple statistics about the number of wells geographically over the area, and you can see the test and monitoring wells, and those are by far the most frequently type of well that has been drilled and reported in the literature, and you get some statistics concerning average number of wells per section, as well as the variation in the number of wells per section.

And I am not going to go through that as it is pretty straightforward to see. Going back to the amount of drilling on the next slide, you get a similar distribution physically, and as you can see the Beatty site again comes up as an area of concentration and drilling.

Also, the Lathrop wells intersection. And so what this particular illustration depicts is the amount of drilling that has occurred within a particular section. So, in summary, what we have done is that we have provided an initial presentation of this literature review at the HEU meeting this past spring in Washington, D.C.

And in terms of a long range goal, what we would like to do is kind of summarize this analysis in the NEUREG, and add a Part A and a Part B to that NEUREG if you will, which is not up on the slide I regret.

But Part A would be just the literature review of the data sources that we examined, and then in Part B provide the drilling statistics summary which we can kind of relate back to that drilling history that we described in Part A. And so that is about it.

CHAIRMAN HORNBERGER: Thanks very much, Mike. Questions? Raymond?

VICE CHAIRMAN WYNER: No. John.

DR. GARRICK: I take it, Mike, that there was no chemical analysis associated with what you were doing?

MR. LEE: No, we didn't look at any water chemistry. We basically in terms of the data, the drilling data, we were concerned with physically where the drilling had taken place, and we just focused on three statistics.

One, what we understood to be the purposes of the drilling, and two, what the total amount of drilling at a particular location was for a particular well; and, three, what the depth of the water table was that was reported.

So those are the only three statistics that we looked at.

DR. GARRICK: Okay. You didn't look at the use of the wells?

MR. LEE: Well, that would be --

DR. GARRICK: The use?

MR. LEE: Yes.

CHAIRMAN HORNBERGER: Mike, I have just a curiosity question. Do you have any knowledge of whether there have been analyses, radiological analyses done on any of these wells?

Do we have background information on any of that?

DR. LEE: I am not sure. I think the one thing that could be done is that you could go back to, for example, the USGS database and frequently they have -- every well that is in the database has a unique classification, and I have not interrogated the database for that purpose, but I would think that if you go in there, there may be some information on water chemistry, or other chemical types of analyses.

I know that when you interrogate the State of Nevada database that it is not always clear. You know what the purpose of the drilling is for, but you don't necessarily know if there was any other types of analyses other than well logs that reflected the drilling.

I mean, in reviewing the literature, for example, there is -- we could tell from the literature that some of the wells have chemical analyses associated with Clausen, for example, and when you look at the drilling activity for a number of the wells within NTS has some chemical analyses there.

CHAIRMAN HORNBERGER: Do you care to speculate on what the next technological advancement will be to the next holes in well drilling in Amargosa Valley will be?

DR. LEE: No. We just tried to present

the facts. We didn't speculate too much on the future. As you can the NAS said that is not a wise thing to do.

MR. LEVENSON: This is a detailed information question. What are the little red cross-sections on the figures?

MR. LEE: Sure. I think that Dr. Levenson is referring back to Slide 13 or Slide 16. The hatchard (phonetic) areas identify areas that are patented. These are lines that were once public that are now privately owned.

And as part of the Desert Lands Act, I believe, what one could do is go in and homestead on a particular location and within a period of three years develop an irrigation plan and actually irrigate a certain percentage of the acres within the bottom line.

I think it was that you are entitled up to a section or a quarter-section. My recollection is a little vague, but generally the game plan was that you could go ahead and stake out -- you could take title of the land after you first developed the well and showed that you could go ahead and irrigate the land, and then pay a fee for the land, which was a modest fee.

So what we thought would be valuable was in terms of showing the distribution growing in the context of where these patented lands exist.

MR. LEVENSON: I understand then why the bulk of them are right where there is a bunch of wells, and the wells came after, and it is irrelevant to our subject.

But I am curious as down in the far right-hand corner there is a huge area cross-hatched in red, and no indication of any wells.

MR. LEE: That is Pahrump, and that is the hydrographic basin that we didn't look at data for. The data does exist, but that is beyond our range of interest.

CHAIRMAN HORNBERGER: Any questions by the staff?

VICE CHAIRMAN WYMER: It wasn't in your scope what I am about to ask, but maybe you know something about it. In all of these drilling and pumping has there been any changes in the direction of the --

MR. LEE: That was beyond the scope of the analysis. In fact, we didn't collect data for that purpose. We were more interested in -- and as I stated earlier, and as Tim alluded to, this was just of an analysis -- well, the documentation activity that we are talking about is more of a culmination of staff work over about six years, in terms of reviewing the literature.

And we thought it was useful before we had the loss of institutional knowledge or staff reassignments, just to kind of document what we saw in the literature. But the short answer is no.

CHAIRMAN HORNBERGER: Any other questions or comments? Jack.

MR. PARROTT: Jack Parrott, NRC staff. I missed the beginning of your presentation and I apologize if you have answered this already. But is this data only for completed water wells?

MR. LEE: No, this data was -- the data that we looked at that was provided or is publicly available from the USGS or the State of Nevada, is drilling by all types.

Not all drilling is associated with the development of a wealth of water, and some drilling may be for purposes of test or monitoring, and in terms of exploration, it is not always clear what the nature of the drilling was for.

Some wells are identified as unused, and so drilling may have been intended for certain activity, and just not –- well, the well was not developed for whatever reason.

MR. PARROTT: But the purpose was to explore for water, versus bore well drilling, or mineral resources?

MR. LEE: Oh, I see what you are saying. Well, it is not -- that is not always clear from the literature. Drilling could have been for exploration purposes, but they don't specify whether they were looking for fuel or not, or minerals, or evaluating the hydrothermal resource, which we know there was a lot of interest in during the initial oil embargo in the early `70s.

MR. PARROTT: Okay. Thank you.

CHAIRMAN HORNBERGER: Other questions or comments? We have to use the microphone for the recorder.

DR. PETERMAN: Zell Peterman, USGS, and I just wanted to mention that we have been working on what we call an integrated hydrochemical license database for about the last four years or so, or maybe longer, and it was scheduled -- you know, it is a living database that continues to be updated, and it was scheduled for release last fall.

Unfortunately, I had to pull a key person off to work on the Chlorine 36 validation, and so it is way behind schedule. But it has also been integrated into the environmental restoration database, which I think is available to the public.

So it is a nice -- I think it is a more up to date than the broader USGS database, and so it is available, you know.

MR. LEE: Maybe after finishing here, you can just give me a reference to that.

CHAIRMAN HORNBERGER: Zell, before you leave, that leads to another question. Are there chemical data associated with that? Is that what you said?

DR. PETERMAN: Yes. We have incorporated the chemistry that we can find, and there is an awful lot of isotopic data in there, too; stable isotopes, and radio carbon, and we try to make it just as comprehensive as possible.

One of our goals continues to be making a user friendly database, where there is multiple analyses from single wells, and then we would use our judgment to select the best composition, and have sort of a derivative database that would be a little more user-friendly than just having everything.

You know, like J-13, there is upteenth

analyses of J-13, and some of them are good and some of them are bad, and I think we know which ones are good. You know, to a single composition.

MR. LEE: Well, one of the infractions that this analysis is guilty of is that often databases are put together for other reasons, and we look at them for totally different reasons.

And as we get into the documentation, we try to acknowledge that we are guilty of that. But nevertheless, there is some insight into looking at these data, in terms of getting a sense for how much drilling as taken place, and where, and for what purpose.

Just what our intent was is to report what we see in those data.

MR. LEVENSON: I have a slightly different type of questions. Has the USGS ever considered archiving samples, particularly from wells and areas which are controversial, with the idea that 20 or 30 years from now, we are going to have different analytical techniques, and we are going to be looking at different things.

Has that issue ever come up with the USGS as being the custodian of archival things?

DR. PETERMAN: You know, I don't think --

the big analyst is the National Water Quality Lab at the Federal Center, and I don't believe they archive samples.

Now, for the isotope work, we never throw a sample away. We have got every sample that we have ever analyzed. So we have our own sort of mini-archive, but in a broader scale, I am not aware of that, but that is a good idea. I remember this coming up before.

DR. GARRICK: The radio isotope work that you have done, has it been sufficient to give you some sense of a spacial in timing, and a variation of the isotopes?

DR. PETERMAN: Certainly a special variation, and combining the isotopes with some of the more conservative elements, like fluoride, or sodium, and things like that.

We have some very nice patterns which we think are mapping flow paths and flow zones, or domains, or whatever. And so that sort of thing. The radio carbon work, you know, we have got a lot of conventional radio carbon data, and that is an emerging dataset just on dating the organic carbon separated, and I think it gives a more meaningful estimate.

And right now there is not that much difference between the two methods.

DR. GARRICK: And that was going to be my follow-up.

DR. PETERMAN: They are pretty darn close.

CHAIRMAN HORNBERGER: Thanks very much. Any other –- yes?

MR. SHETTEL: Don Shettel for the State of Nevada. This is an very interesting study, but I think the main point of this should have been perhaps the amount of water that was used over this time period, and then you might have been able to make some trends, or at least perhaps future predictions of water usage in this area might have been evident.

MR. LEE: You can't always get a sense from looking at the data how much water has been used, and as I tried to note earlier, our principal concern –- the documentation here wasn't intended to satisfy any specific staff activity or product. It was more of an intent to kind of just document our historic knowledge, in terms of the information that we looked at.

At least for this documentation exercise, my specific interest wasn't looking at how much water has been pumped, or how much water has been used.

MR. SHETTEL: That should be perhaps part of the historical record, and it would be very interesting.

MR. LEE: Well, I know as the authority responsible for regulating water use, I think that might be an issue that the State of Nevada may have a better sense for. I am somewhat removed from the data.

MR. SHETTEL: That is probably part of the State Engineer's database, perhaps. I don't know personally. Just an idea.

MR. LEE: Thank you.

CHAIRMAN HORNBERGER: Thanks a lot, Mike. We have had enough feedback to lead you to your next three papers. I think we are going to proceed, and I believe everyone is here. We know that our speaker is here.

And so we have a program next that is for a DOE scientific update, and we have several things, or two things, two main things that we are going to consider this afternoon.

The first is an update on the Chlorine 36, and I think probably everybody knows that the finding of Chlorine 36 at the repository in Horizon at least five years ago led to some reappraisal of fast flow paths, and potential fast flow paths to the repository arising.

And later there was some -- a different laboratory had done some analyses and there is now some work trying to work towards a resolution of differences that were observed.

So, Zell Peterman is going to give us an update.

DR. PETERMAN: Let me mention before I start that there is a significant part of the Chlorine 36 validation team here today. Bob Robeck from Los Alamos has taken over the work down there, and Greg Nimz from Livermore, who actually does the Chlorine 36 analyses, and my colleague from Denver, Leonid Neymark, who had been heavily involved in the design and the sensitize design and the sensitize related to the validation project.

The first slide, I gave something similar to this several weeks ago to the BSE Project Oversight Board, and Bob Thorsen (phonetic) observed that I had 15 pages of history and no conclusions regarding the validation project, and nothing has really changed.

But let me just jump to the conclusions first, and then work our way through this history. We thought it was important to try to give a historical perspective as we think we understand it.

And over the last 3 years, we have generated a lot of data, and we have given a lot of thought on how to try to validate the work. We have done a number of experiments, and we have a lot of information.

And our immediate goal is to sensitize and integrate all these datasets in to a report that is due in December. And that in that report that after doing all of this, and really having time to think about the data, we will develop a path forward. Right now we don't have that. The report is our path forward.

But there will be in that report presumably a path forward that leads to hopefully some sort of resolution. And that is kind of where we are, and let me just go through this.

I have a lot of slides, and I don't want to go and read every bullet, but let me just try to summarize. Sometime in early Fiscal Year '96, when the ESF was being constructed, there were two studies that were started.

One was Chlorine 36, and the other was a study of fracture minerals, fracture minerals being the only physical evidence of percolation through the unsaturated zone at Yucca Mountain.

Los Alamos conducted the Chlorine 36 work, and USGS conducted the fracture mineral study, and basically we both sort of followed the TBM as it made a tunnel and collected our respective samples. Next slide, please.

Early on when it was evident when elevated Chlorine 36 values were found, we had a meeting in Denver, and the Los Alamos' folks, and the Denver folks, and we really struggled with what this meant, and how we were going to validate it.

We talked about doing deturium, technesium 99, and iodine 129. There was a very early attempt by the USGS to look for tritium and that pretty much failed because samples were collected from the tunnel walls, and those tunnel walls had been saturated with construction water. Next slide.

The Chlorine 36 worked and continued to the ESF, and into the ACRB as it is referred to. Technesium didn't really get off the ground, and it is really a tuff thing to do.

The work on the fracture minerals, we developed a spectrum, a dataset, for the uranium series that ranged from a few thousand years, a few tens-of-thousands of years for the youngest, outer-most materials, to well over a half-a-million years for the older material.

And then this evolved into a uranium lead-dating system, which now pushes the formation of the older parts of the fracture minerals back to 10 or 11 million years, within a million years or so of when the tuffs were formed. Next slide.

In 199, and I think it actually started in late '98, the DOE asked the USGS to organize a validation project that could independently verify the presence of bomb pulse Chlorine 36 or not in the exploratory studies facility.

The final proposal, and what we put together, involved the USGS, Lawrence, Livermore, and AECL, and Los Alamos, as an oversight –- to provide oversight for the validation work.

The first organizational meeting was held in the spring of 1999. Next slide. This was the dataset at that time that we were asked to look at and basically on the wire access to the Chlorine 36 over chloride ratio, times 10 to the minus 15, and it says maximum twice the same.

And that was considered anything above that line was considered to be bomb pulse. The little XXs is just distance from the north portal through the

ESF, and the anomaly in the middle there is associated with the Sundance Fault.

And we refer to that as the Sundance Anomaly. And just another point, there is an anomaly to the left of that that is composed of about five samples, and that is the drill hole life feature. So that is kind of what we were looking at. The next slide, please.

So we tried to design a sampling from it, and we decided to look at the Sundance anomaly, and the Drill Hole Wash anomaly. And we went to the tunnel, and we looked at all of the sample sites, sites that had been sampled by Los Alamos.

And we looked at all three maps to assess fracture spacing and that sort of thing from the Bureau of Reclamation mapping. Because of the -- the dataset that you just saw was developed from samples that were largely collected from the right rib of the ESF, the lower quarter, because a lot of them were collected by jackhammer.

And by the time that the validation work started, that lower quarter of the ESF had been washed down so many times to clean walls or control dust, that it was decided that it decided that we were not going to try to collect samples from there again. So the next slide, please.

So it was decided that we would build four meter long bore holes, dry drill 50 of these, and 40 spaced along the Sundance anomaly and 10 spaced along the drill hole wash anomaly.

It had several advances. It goes us in past dry out and it got us in past infiltration by construction water. A lot of the surface or tunnel wall samples had to be corrected.

The data had to be corrected for the presence of construction water, and by going in four meters and preserving the core, then we could also extract water and conduct treading analyses.

One thing I have failed to include in this history is that there was a peer review panel at the Chlorine 36 dataset, and that peer review, one theme that kept recurring is that you have got to go in and try to do tritium.

So this was an opportunity also to do tritium. Next slide, please. We were delayed at that point, and there was a multi-month safety stand down. I can't even remember what caused it now, but that delayed things for several months.

There was a bit of a problem in getting all the perceived QA procedures going at Livermore.

Anyway, the holes were finally drilled, and we looked only at the deeper two meters from the construction water and dry out.

We sub-sampled or we sent samples for Lawrence Liverman, and we took samples to Denver for water analysis and tritium, and we sent samples to AECL for uranium isotopes.

The Livermore -- the first Livermore dataset was developed by an active leaching process, with seven hours in a rotating tumbler; in contrast to the previous Los Alamos methods, which was a passive leach for 24 to 48 hours. Next slide.

The first Livermore results were presented at the NWTRB Chair meeting in Pahrump, and the values were lower than had been observed, and basically it was concluded that that leaching technique was probably too aggressive, and we were getting too large a component of rock fluoride.

If the rocks are multiple reservoir chloride, there would be chloride initially in the volcanic rocks, and I think the average for the high silica is something like 170 ppm chloride, and this is primary chloride.

There would be chloride in the four moderate in there would be chloride in fracture order, and presumably what you want to look at for finding bomb pulse is to try to look at fracture water, which you can't -- nobody has sampled fracture water, but you can sample the salts. You can leach the salts.

So you try to balance the leaching to maximize the meteor component, and minimize the rock component. Anyway, next slide. So there was general agreement that the dynamic leaching was a little too aggressive, and there was an agreement among all participants at that time that we needed really to rest, have a sample to test the bleaching process.

And the USGS was charged with preparing that sample, which we did. TRB too a very intense interest in this, and wrote a letter to the OCRWM Director urging a quick resolution, and that was on June 16th of 2000. Unfortunately, we are still not there.

We developed a path forward, and we got a large sample from Niche-5 in the cross-drift. This was crushed and sized in Denver, and aliquots were sent to both Livermore and Los Alamos to conduct leaching studies. Next, please.

These results were discussed at several meetings, and there was a meeting in November of 2000 at the GSA meeting in Reno. Next slide. The bottom line is that it was decided that the best way to go about it was a passive leach, and to minimize the time.

And at that time one hour was sort of indicated as a desirable time for leaching of that size of a fraction rock, even though that was in somewhat of a contradiction with the earlier dataset, where samples were leached from 24 to 48 hours. Next slide, please.

So we needed to go back now and look at the validation core again, and the approach this time was we would crush the samples, and actually the sample management facility crushed the samples, and some of the remaining core, and this was done in basically a brand new crusher.

The only thing that it had ever seen before was other samples of the Topopah Spring type. Samples were transported to Denver, and the USGS leached the samples, and distributed aliquots of the leach samples to Los Alamos and Lawrence Livermore, both of which then spiked the samples with different chloride isotopes, and prepared the silver fluoride precipitates, and Lawrence Livermore ran the samples.

And generally the results were in fairly good agreement between samples prepared at Los Alamos and samples prepared at Livermore. The numbers ranged from 200 times 10 to the minus 15, to 500 times 10 to the minus 15, still lower than the previous Los Alamos dataset.

At a meeting last January, we convened the group in Denver, and we looked at the data, and there was one dataset in the old Los Alamos data where core from Niche-5 had been analyzed, or I'm sorry, Niche-1, had been analyzed, and something like 8 out of the 10 samples that were analyzed revealed an elevated chloride 16 value.

And so we thought, well, this is what we need to do. First of all, we had a hard time finding the core. It turned out that some of it was in the USGS hydrological research facility, and most of that had been used for physical property measurements, or had been saturated with J-13 water, and so on and so forth. But there was still a pretty good collection at Los Alamos. So we split the core up. Next slide, please.

And we agreed that we would do -- there was concern that machine crushing might yield too much fresh rock fractures, and therefore, overwhelm the leachable chloride with rock chloride.

So we followed a procedure used at Los

Alamos, which was hand crushing on a steel plate and a hammer. Los Alamos conducted their or analyzed their six samples, and they reported ratios of 1140 times 10 to the minus 15, to 8580 times 10 to the minus 15.

That is the highest or largest number that has been reported so far. Chloride concentrations were 1.3 to .67 milligrams per liter, and we processed what should have been roughly an equivalent core in Denver, and we got ratios between 244 and 708 times 10 to the minus 15.

Both groups had monitored leaching blanks during that time and no leaching blanks were deemed to be acceptable. So that is the most recent puzzlement as to why these numbers differ.

CHAIRMAN HORNBERGER: Can I ask a question on this, Zell? On the previous go around, the USGS did the leaching and distributed the aliquots. Here two different labs did the leaching.

Why did you do that apart from -- am I reading this slide correctly, that leaching was done both by USGS and Los Alamos? Whereas, previously it was done just by USGS?

DR. PETTERMAN: That's correct, and it was because of that, because previously it had shown that if one lab leached a sample, and distributed the liquid leaches, both labs could get the same answer.

So we were back to –- and we had already demonstrated that to be true. So now we had another chance, and the early Los Alamos data had said there were elevated values, and so we just decided it was best to let's just let those -- we didn't physically split it. It was pretty rumblized, and so Bob Robeck had inventoried what was available.

And we took alternate -- I don't know, either one foot or six inch segments of rumblized core, half to Denver and half to Los Alamos.

It should be, you know, unless fate is really cruel, they should be comparable. The statistics, the probability, of them being or leading to these results is extremely low.

The bottom line though was that we got different results, and again the leaching blanks were okay at both laboratories. So we decided that one thing that we did not have control on was the actual crushing blanks.

So we got a hold of some computer chip silicone from the DOE lab in Golden, the Energy lab, and supposedly pure to six figures. And we crushed it just like it were a rock, and using the same equipment, and we also conducted a systems blank at that time.

Unfortunately, our system blank, which basically is pretending we have a rock and leaching it, but there is no rock in the pan, our system blank was a bit higher than what we had seen before, which has confounded the issue.

But if we correct our crushing blanks for that leaching blank, then our blanks, the crushing blank, we have concluded is not a significant issue by the USGS in Denver.

At the same time, Bob Robeck had surplus material from one of the core samples, which he sent to Denver, and we leached it, and we got essentially the same number that he did, 1130 times 10 to the minus 15.

So that we could confirm, and that is kind of where we are at the moment. And I think that it is very important, and that we have so much data now, and so many efforts to try to resolve this issue, that let me try to go through the conclusions here.

So this is kind of a summary. The old or the early dataset at Los Alamos, samples from both ESF and Niche-1, and this is the Sundance anomaly now, had elevated Chlorine 36 values.

The Los Alamos data on the Niche-1 core, the most recent analyses, had elevated Chlorine 36 values. An early effort, and I think six samples of the original Chlorine 36 validation core were analyzed at Los Alamos from the Sundance.

Those did not have elevated values, but the numbers were in the normal background range to the Los Alamos dataset. Next slide.

The lowest values measured was that original dataset at Los Alamos, or I'm sorry, at Livermore, and the active leaching. And then next we found no bomb pulse in the validation core holes, and we found no bomb pulse in the Niche-1 samples. Next slide.

So I think we are at a critical juncture here, and it is extremely important that we have the time to sensitize and integrate the existing data, and after doing that, then come up with a path forward.

And to be honest, we just don't know what that is at the moment, but we think that putting all these data and having time to think about the data in a report is a next very logical step.

The project has indicated that they could bring one or more outside experts in to review the report and whatever path forward we come up with.

Let's go to one of the illustrations here, and maybe that summarizes -- let's see, how about page 29.

These are all the data now plotted on the -– the Y axis is one over chloride, and the reason we do that is that in this ratio concentration space, if you plot the reciprocal concentration, then binnery mixing comes out as a straight line. That is the only reason.

But the chloride concentrations is also shown on the upper access. The triangles down in the lower left-hand part are the Livermore results, and the active leaching of the chloride validation core.

So that is one set of data. The solid blue diamonds are the original Los Alamos dataset for the Sundance Anomaly, and this is all Sundance Anomaly. The orange triangles are the results, the second round of results on the Chlorine 36 validation core processed and leached in Denver, and analyzed at Livermore, but aliquots also to Los Alamos, and spiked at Los Alamos, and analyzed at Livermore.

And those are the interspersed green triangles in that field of orange triangles. So there is general agreement, and then the largest value is that kind of open diamond, and represents the most recent Los Alamos data on the Niche-1 core.

And the little purplish triangles down amongst the orange ones are the USGS results on the Niche-1 core, both analyzed by Livermore. So again that is kind of where we are, and I know that it is not satisfying, and I think we have made progress.

I think we need three months now to prepare the report, and I think we have to go into what I would call kind of a forensic mode, and we have got to really get into the old dataset, and really look at it hard, and see if there is anything in there that would be of interest in reconstructing how this has evolved.

CHAIRMAN HORNBERGER: All right. Thank you. Questions? Raymond.

VICE CHAIRMAN WYMER: It must be a little disappointing to you that after all this time that we still have something unresolved.

DR. PETERMAN: It is extremely frustrating.

VICE CHAIRMAN WYMER: But there is a suggestion at least that at least to the Sundance Fault, that there is some evidence for fairly rapid movement of water into the repository horizon, and that is one part of the two-part equation, and how fast does it move.

But the second part is what volume moves, because not much has moved, and you don't really care with respect to the proposed repository. What do you know, or what do you plan to know, or what does somebody plan to know about the volume?

DR. PETERMAN: Well, I think that is more of a modeling exercise and Los Alamos has addressed that, and has concluded that the actual volume of water is probably small.

Now, I see that there is a flaw in this presentation. The dataset that I didn't mention was the tritium data, which we have also done on these 50 core. And there again we have got another disconnect.

And in the Sundance Anomaly, we find no tritium of any consequence. I mean, no tritium, period. It is down to one tritium unit. In the south ramp, where there is no elevated Chlorine 36 values, we find significant tritium values.

So we have an anti-correlation between tritium and Chlorine 36, even though the peer review said that tritium is the ultimate hope for validating the Chlorine 36.

But you can come up with post-hoc explanations for tritium, and it is going to move into the vapor phase, and Chlorine 36, probably not. So you can come up with reasons why they might not agree

DR. GARRICK: How much cross-checking of samples has there been in the analysis? Different labs and even outside of the established --

DR. PETERMAN: I would refer that question to Greg Nimz, who actually conducts the analysis. I'm sorry, but I a not sure that I understand the question. Are you asking how much cross-checking within the samples that we have done in the last two years under this validation, or cross-checking in general between laboratories?

DR. GARRICK: Let's try and answer both of them. Both sound interesting to me.

MR. NIMZ: Well, the best cross-checking is probably the samples that were prepared at Livermore Laboratory and at Los Alamos, and a little more at the Livermore Laboratory, and we get very good agreement as Zell pointed out in those.

Cross-checking around the world has not been done except for sample response activity, where one lb send this to the -- the same sample or a similar sample, to two different laboratories for purposes of turnaround time and that sort of thing.

And then in general analyses, the clean

laboratories, especially I am familiar with the prime laboratory in Indiana and Livermore. Those analyses have generally compared very well.

DR. GARRICK: Have the results had any impact on the models that are being used to analyze radionuclide transport?

MR. NIMZ: I don't know the answer to that.

DR. PETERMAN: Let me ask this question of Abe Van Link, and of course, and he says no.

MR. VAN LINK: since we assume that this data is correct, and it is fully incorporated into the modeling, and until some definitive group comes in and says that it isn't correct, we would not change the model.

However, the very fact that we also have some tritium in the south ramp shows that some very small fraction as the model now indicates can move rapidly. So probably the model wouldn't change anyway even if this data came in. But it is a scientific credibility issue for us.

DR. GARRICK: Thank you. Has there been any indication of any gradance of this transport of the chlorine, any particular location that has indicated a more definitive flow pattern than maybe you knew about before?

DR. PETERMAN: Well, the original dataset has been used or explanations have been put forth on that slide number six, which is the original Los Alamos dataset.

Again, there are contradictions. The south ramp, among the whole of the ESF, the south ramp is the most broken up piece of rock. It is highly pallid, and there are fractures there that when it was drilled, it was breathing to the atmosphere and blowing to the atmosphere.

And the contradiction there is that there have been no bomb-pulse Chlorine 36 values found there, but again there is tritium there, and so it is still a set of contradictions.

And with those sorts of contradictions, I guess I would be personally reluctant to say that I am going to use these patterns to say too much about specific flow paths or flow zones within ESF, because there is still something that we don't understand.

CHAIRMAN HORNBERGER: Zell, let me try to summarize what I take from your presentation. The accelerator mass spectrometer appear to work. That is, they give you the same answer if you give them different aliquots.

DR. PETERMAN: That's right.

CHAIRMAN HORNBERGER: You get, however, different answers when different labs prepare or do the crushing. So am I right in inferring that this would either indicate that the USGS crushing adds an anomalous amount of dead chlorine, or Los Alamos adds an unusual amount of elevated Chlorine 36; is that a fair assessment?

DR. PETERMAN: I think that is a fair assessment. That's one thing that we tried to look at by this crushing blank, which turned out to be somewhat confounded by the fact that apparently a leach wire suddenly was higher in chlorine than we thought it was when we actually did the earlier samples, or it was higher than when we did the earlier samples.

So we have to make some assumptions about calculating the crushing blank. If we use the leach blank that was conducted at the same time as the crushing blank, then we conclude that crushing doesn't add anything significant.

But it is a complication that makes one feel a bit uncomfortable still.

CHAIRMAN HORNBERGER: And I take your point that you really need three months to reflect on this and come forward with a plan, but in general terms, do you anticipate that it might be reasonable to plan to involve other groups, groups that have not yet been involved in the process, in terms of trying to resolve this?

DR. PETERMAN: I think the project is considering that. I don't know if the DOE wants to make a comment on that.

CHAIRMAN HORNBERGER: My question wasn't what the project was considering. My question to you as a geochemist is would that make sense?

DR. PETERMAN: Yes, I would welcome that, personally welcome that, you know. Anything to get this off of dead center.

CHAIRMAN HORNBERGER: Milt.

MR. LEVENSON: I have got a couple of questions. In one of your backup slides, you identify that the mechanical crushing equipment at Los Alamos was found to be contained with chlorine 36.

Now, that contamination didn't originate in the crusher. What are the chances of other things in that laboratory are also contaminated? Has there been a sort of forensic search of that laboratory to make sure that it is a clean laboratory?

DR. PETERMAN: Bob Robeck, who has taken

over the Chlorine 36, actually works in a different laboratory than that earlier work was conducted in. The contaminated equipment was reported in that earliest Chlorine 36 report.

It was detected and that's why basically they went to the steel plate and hammer rather than the mechanical crushing.

MR. LEVENSON: But contamination at the level of 10 to the minus 15, some of my experience is that something in a building is contaminated, and everything in that building might well be contaminated at that level.

And changing equipment, or even the lab next door, doesn't necessarily help. The other question that I had in connection with the anomalous tritium, I have the impression, and like many impressions, it could be wrong.

But I have the impression that some of the drilling equipment that the DOE is using or has used is recycled equipment from the testing station. Has anybody looked seriously as to whether the tritium is contamination brought in my drilling equipment?

DR. PETERMAN: Early on -- and this is only sort of an antidotal recollection on my part, but there was some contaminate drilling equipment used in some of the surface-based drilling.

The drilling that was done underground, we used brand new core barrels, and brand new bits, and new core liners, in anticipation that we did not want to have that possibility.

And the possibility that through the ESF, through the Sundance, and drill hole wash anomaly, we don't find any. And the same equipment was used in the south ramp, and we sort of would say that equipment is not a problem.

There was also in the lab, the survey lab, there were early problems. The exit signs were triturated, and so that created problems. And your watch, if you have a triturated dial, you don't want to be in there when you are extracting water. So, yes, it is a tuff ball game.

MR. LEVENSON: Is the tritium contamination in the south ramp been found in cores or only in surface material?

DR. PETERMAN: The south ramp is water extracted from dry bill core. Those are all by vacuum distillation, and taking the preserved core, and distilling it in a vacuum line.

CHAIRMAN HORNBERGER: Staff. Andy.

DR. CAMPBELL: Thanks. I have a lot of

questions. Andy Campbell, ACNW staff. But I am going to try to touch only a couple of them. Why is Iodine 129 not done? Is there a technical reason?

And the reason that I ask that is Chlorine 36 was produced in the `50s by bomb testing in the Pacific, because of the irradiation and activation of chlorine in the sea salt.

Tritium was actually mainly produced in the tests in the atmosphere, in the hydrogen bomb tests in the `60s after the breakdown of the test data. The iodine, on the other hand, also has a source from pre-processing in Sullyfield and the other reprocessing plant in France.

And, of course, various programs around the world have been putting out Iodine 29 for a long period of time. So if you are seeing the penetration of these isotopes to the repository, then Iodine 29 might be a good trace, that of more recent activity, as compared to activity produced in the `50s and early `60s.

That is a question I guess for you, and then I will ask another.

DR. PETERMAN: That's interesting, as we were just talking about that at lunchtime. When Mark Haffey was doing the work at Livermore, he was moving in that direction, and I don't really know how far he really got. Drake would know. He took a position at Purdue to oversee the AMS facility there.

And so basically we have not pursued. Greg, do you want to say anything about 129?

MR. NIMZ: Yes, the only point I would make is that it would be analytically very difficult, really tuff right now with the amount of chloride that we are getting from these samples.

And the amount of iodine is going to be much less. So there is a very big question as to whether we would even be able to analyze the iodine, which would occur in concentrations of perhaps of a factor of a hundred less than chloride.

So there is that analytical junk that we would have to make, which would take several months of preparation to just understand whether we could do iodine with these very little concentrations when we are doing this passive leachings.

DR. CAMPBELL: Okay. The next question or questions has to do with the approaches used to resolve contamination when you are doing trace analyses.

This certainly is the first example of a contamination issue, and the fact that virtually every trace analysis of either an isotope or of a metal have involved a number of years of kind of floundering around until everybody agrees on a methodology, and everybody agrees on an approach, and the way to do it, and then people start getting consistent results.

Part of that process involves systematically going through and identifying every single possible source of contamination in every step along the way. And it is not clear to me at least from how these analyses have been done in terms of the selection of samples, and not really analyzing the same thing.

And it is not clear, for example, that a reference material has been produced that has a known concentration that each lab can include in a set of samples to check on the validity of their analyses.

You typically do a check sample that is very similar in matrix to the samples that you are analyzing. Part of the problem, for example, is doing distilled water and leech blanks, is that you don't always get the same activities going on that you would if you include a crushed sample and so on.

And there are all kinds of wrinkles on this process, and it is very detailed, and it is very obsessive for the analyst to do it, but it has to be done to eventually ferret out if there is in fact a contamination issue.

Is that all going to be what you guys have done folded into this report so that an objective outsider can say, ahha, have they looked at this area and have they looked at that area.

And are there any further activities that you plan to do to try and nail this down. The other thing that people have done are inter-calibration exercises, where they take the same sample, and distribute it to half-a-dozen or a dozen labs to do that analysis.

And let each lab work up that sample, and then do a comparison, a blind comparison of the results, to see if any particular lab either has either or very low numbers, and could you comment on that?

DR. PETERMAN: Well, I guess I would agree with everything that you said there. It needs to be done, and we have probably done some of it. I think we will address those issues in the report, and it will be part of our recommendations for a path forward.

Part of it, you know, is always a resource issue. You know, it is expensive analyses, and a collection of samples that are less labor intensive, and it doesn't take very long to burn up your budget.

And that is always an issue, but I agree with everything that you said. I am certainly aware of some of those historical problems in working at that level.

We asked Greg at lunchtime how many folks the world over have rocks that have chlorine 36, and he said it is only you guys. I think there was an additional comment there which I won't pass on.

So the point is that it is not something that is routine, and we do need to think about everything that you said.

DR. CAMPBELL: One last comment on the view graph up there at the three different years worth of data. The interpretation as I recall from the '97 report was that the high spikes that are categorized as bomb-pulse above the maximum level were interpreted to be bomb-pulse in association with fractures or faults. There are a few exceptions, but mainly those data are.

But below the maximum and above the lines, there is a lot of scatter in the data until you get to 6,000. And then the data gets very tight. And there were two explanations for that that I am aware of.

One was that something happens at 6,000 that causes a flushing of the system, and the scattering of the data before 6,000 might be representing different amounts of pre-plisticing (phonetic) water of different Chlorine 36 contents due to changes in the magnetic field.

Bill Murphy at the Center did a statistical analysis, and said, well, you could explain all of that scatter below 6,000 as simply a two-hand mixture of bomb-pulse contamination and modern water pre-bombed modern water.

If that is the case, then it seems that you actually have to nail this issue down even if the model attempts to take into account fast paths, because the one interpretation might be that that scatter represents a lot more fast paths than just a few fractions.

You could certainly reasonably interpret that data in that way. This is real and not due to contaminated samples, and then that would suggest that its more important than just for a few fractures. It might be important for a significant portion of the rock.

DR. PETERMAN: Well, that's true, and also that a similar lab arrived at a similar interpretation, and that could explain all of that. Most of it, except for the south ramp, and virtually every sample, or most every sample there has a little bit, variable proportions of bomb-pulse chlorine 36, and reasonable interpretation.

MR. ROBECK: I am Bob Robeck from Los Alamos, and I took over the project from June about two years ago, and have been working and puzzled by this issue ever since. It has been a frustrating experience scientifically for me.

There has been a lot of talk -- well, first of all, what you were saying over there, I agree. Where the project is now, I think we have eliminated a lot of first quarter issues that we have been able to come up with through a considerable amount of discussion and meetings.

And we said, well, let's get a reference sample and try to develop a reference sample that we can both work on. We tried that and we tried -- the GS tried leaching and distributing (inaudible), and I cross-sampled and sent them to Zell, and Zell has cross-sampled.

And we are working through the first order problems, and now we still don't have the answers, and now we need to get to the difficult issues to address.

And can we be missing something at the very low level, or perhaps are we looking at more than one problem rearing its ugly head, and from time to time another problem perhaps rears its head at another time.

Personally, I think that's where we are right now, and I don't think we have a single issue, and a lot has been said about the blank issue, and I just wanted to address that.

When I took over the operation, it was shortly after the fire at Los Alamos, and as a result of the fire, I was no longer able to do the work the laboratory that had been used previously by June. So I relocated the entire operation about a mile way in a completely different technical area, and a completely different building.

I vigorously blanked that area, and the blanks came up low, and that area is a non-rad area within Los Alamos. I also modified the procedures so that we could keep careful tabs of the blanks.

Through the course of the analyses now, I have run some 100 samples and no fewer than about 15 percent of those are blanks. And every one of them has come up quite low.

So that any contribution to Chlorine 36 by the blank would not be significant, or would not change any of the conclusions. The blanks that I have taken do not include a crushing blank which is yet an issue.

However, when we do a leach blank, we allow that leach to sit out that length of the time that we take to drive down our samples, which is sometimes up to a week.

Whereas, we are crushing for approximately an hour to maybe a few hours within that laboratory. So I think any kind of fallout that we might get from our crushing equipment, and I don't see where else it could come from because the equipment is vigorously cleaned.

So I think that we have done our best at least to address the blank issue at this point, and perhaps we need to take it a little further. But I also wanted to say that the data that we have generated do not in any way suggest that a random blank is the problem here.

We are not seeing a random high ratio. Rather, we are seeing ratios where they have been determined in the past. So, for instance, he has ditched one sample, and let me jump back.

Of the close to a hundred samples that I have analyzed thus far, only one sample from the cross-drip has what we would consider a bomb-pulse value, which is just barely bomb-pulse value, between 1200 and 1300.

And then when we did this Niche-1 samples, again processing them in the same way, most of them did turn up to have bomb-pulse in the same area where June located bomb-pulse, using modified methods in different laboratories.

Likewise, I processed this Niche-1 samples and did a couple of different experiments, and separated them by size fractions, and you see systematic differences within those size fractions.

And in this case the highest bomb-pulse turned up in the finest fractions, but again the systematics that we see from low ratios to high ratios, and low chloride to high chloride for corresponding samples do not smell like a blank problem.

You would not expect those kinds of systematics. I might also point out, too, June's dataset, where most of these bomb-pulse values that she did find are from her feeder base samples.

Whereas, within her systematic sample set, I believe that only one sample has turned up bomb-pulse. We are certainly concerned about the blank issue, and I am doing what I can to address it further, and we will continue to do that.

But right now I firmly believe that the data does not suggest that a blank is an issue. I don't know what the problem is and hopefully -- and I think that our path forward, we really do need to step back here and look at all of this data. For the last two years, we have been working hard to generate a lot of data, and I don't think we have given the dataset justice at this point. So that is our goal for the next two months here.

DR. RYAN: I am looking at the figure on page 6 and I have been thinking here quietly about statistics. And as the ratio gets bigger, that means that there is more Chlorine 36, right? Yet the uncertainty gets bigger as well.

I would think it would be just the other way around in bars that are shown on this graph, and I don't have the data, and so obviously I am shooting in the dark here.

But as the amount of Chlorine 36 gets smaller, and smaller, I would think the uncertainty and your knowledge of its value gets bigger. I mean, that is just simple sampling statistics to my way of thinking.

But yet it is just the opposite on this graph. So I am stuck with the basic statistics question, and that is when you measure Chlorine 36 and say it is this value, I am stuck with how well you know that. So I am trying to figure out if I should interpret things that are below these various horizontal lines as being different or not different.

And I am kind of stuck with the statistics that you used. I know that this is not a radiometric measure. So it is a different kind of uncertainly analysis perhaps. But I don't really have a feel for how accurate any given measure is.

And I know that you can't do it because you would run out of sample, but if I measured the same sample 50 times, what would the average be and what would the standard deviation be?

What I am reaching for is concepts that we use in radiometric analysis of minimum detectable activity, critical level, and things like that which we can do hypothesis testing.

I mean, you have not talked about that here, and I don't know if you have done that, and I apologize if you haven't. I have not seen it yet. But that kind of thinking may be helpful perhaps. I don't know.

DR. PETERMAN: Yes, it is helpful. Attempts to replicate analyses on individual samples, and June reports this in her reports, has not worked very well. Both data are available.

And so – well, Leonid, do you want to comment on these uncertainties? This is Leonid Neymark.

MR. NEYWARK: Just that we started with the largest uncertainties, for example, for Chlorine 36 and there is a reason for that. But in most cases, and in June's data, a bomb-pulse signal was obtained for a sample with lower total chloride concentration, and it increases the total there in that one.

DR. RYAN: That doesn't help me very much though. The more chlorine 36 you have in the sample, you would think that if the measurement quality increases with chlorine 36 concentration that's not true?

MR. NEYWARK: No, it is not. A higher chlorine 36 total chloride ratio doesn't mean that you have more chloride 36 in your sample. It depends on the total chloride concentration. So if those low chloride samples, you have a higher ratio larger.

DR. RYAN: I guess I would like to follow up if I could. That may not be a meaningful error to report then, because are you measuring the ratio or are you measuring the chlorine 36?

MR. NEYWARK: I think it is that if you have less chloride -- generally speaking, if you have less sample to analyze, your accounting statistics is -- you know, you get less counts and therefore your error is larger, regardless of the ratio of chlorine 36 to total fluoride.

The total amount of chlorine 36 are lower because you have lower chloride sample. Is that true?

MR. TYNAN: Let me first say that I know very little about the data on page 6, because this was not done by me. It was done by the laboratories, and so I am not sure what the meaning of the error is on here. But to answer your question, in general, and to follow up on what Leonid was saying, is that this is simply an accounting statistic problem.

If you have a hundred counts of Chlorine 36, you have 10 percent data. And so if you have or if you are running samples, and if the laboratory chooses to run the samples for five minutes, the samples with more Chlorine 36 will have more counts, and therefore, better accounting statistics.

DR. RYAN: I guess I am getting in a very fundamental question of the accuracy and precision of the measurement relative to minimum detectable levels.

And without some understanding of minimum detectable levels relative to measured levels, it is very difficult to either ascribe or take away meaning from the results.

And I assume that just based on what you talked about that we are at very, very low levels to begin with, and I am just going to try to assess some statistical significance to that, and I have not seen information that helps me to do that yet.

MR. TYNAN: Again, I don't know about the data on this sheet.

DR. RYAN: I appreciate that.

DR. GARRICK: One of the questions that this committee often asks is so what with respect to bottom line health and safety issues. I suspect that you have done enough work now on these ratios on chlorine to be able to categorize what the outcome is probably going to be, in terms of it being one or two, or three different scenarios.

In other words, you probably have a pretty good handle on what is going to be the outcome of your path forward if you had the option of identifying two or three possible outcomes.

Given that, and this is probably a question for DOE, and not to you, but what is the implication? Has somebody considered what the implication might be to the project and to the analysis?

Abe Van Link has already said that the assumptions have sort of embodied in reference to what we were talking about earlier, the possible inability to get any advantage from these measurements.

But I am curious as to whether or not this is really going to have much meaning in terms of the project and in terms of the performance assessment. Abe, this is probably a question for you.

MR. VAN LINK: Abe Van Link, DOE. As I have already mentioned, we fully incorporate the information from the Los Alamos work into our performance assessment at this point.

I think where this comes down now is we need to push to a resolution, because we have several august organizations that we rely on for scientific information, who have come to a point where their own scientific credibility is on the line.

So we need to push forward to a resolution because from my perspective it is in our best interests that we get to the bottom of this, and are able to establish or reestablish credibility for these institutions.

Now, if some contamination is found somewhere, so be it. If they find a new mechanism that one organization was not aware of, so be it. Those are the two or three scenarios that we can come up with.

But either way a resolution will bring us reestablished credibility. It is not something that we want to shove under the rug and say, well, it doesn't matter to performance anyway. We want to get to the bottom of it.

DR. GARRICK: What about if it comes up that there is no bomb-pulse or no evidence of it? Is that going to change anything?

MR. VAN LINK: I hate to speculate on that, because as I said, we do have the tritium work on the south ramp that shows that there are fast paths other than the Chlorine 36 paths, and we do have one tritium sample, I believe, that is associated with a fault in Alco 6 or 7.

DR. PETERMAN: Yes.

MR. VAN LINK: So on the other hand, it probably would change our qualitative understanding of the unsaturated zone. You know, we do have -- most of the water there is pristine water still, and we do have very good evidence from Zell's work that if you look at the bulk of the rock, it doesn't see water very often.

It sees it maybe during an ice age, and so this is still consistent with our current model though, that we have very little water moving through fast paths, and the bulk of the water is resident in the rock for extremely long times.

I think that Mark Tynan was going to say something.

MR. TYNAN: Yes, Mark Tynan, DOE. You covered one of the points already, but the second point that I would make is that if our path forward isn't defined until January, let's say, or the reports aren't out, our ability to resolve this prior to the license application is not a high percentage of success.

So it is likely that this is the ongoing work and post-LA submittal in December of '04.

DR. GARRICK: Thank you.

MR. COBEST: Tim Cobest, ACNW staff. I assume that this is all being done under DOE's quality assurance program, have you had an audit done or anything?

Have you had them come in and give you an independent look at it and come up with anything as far as procedures, and as far as how you clean your test equipment that you were talking about?

You know, handling samples, and have they come up with anything or have they looked at it?

MR. TYNAN: Livermore just had an audit, and –

MR. COBEST: And did they look at this issue?

MR. TYNAN: Yes, and we have I think audits at least once a year.

MR. ROBECK: We certainly have audits of our scientific notebooks and our procedures, and those are ongoing. As far as having and testing equipment, it comes and is examine, but as far as someone actually coming in and observing a procedure that doesn't happen.

MR. LEVENSON: The conversation has been focused on Sundance, but in the original samples, and in fact the highest Chlorine 36 ratio was not at Sundance, was a 2,000 meter and five separate samples indicating bomb-debris. Is 2,000 meters still part of the Sundance?

DR. PETERMAN: It is part of the drill

hole life structure, and that was in our initial plan. We allocated 40 of the bore hills to the Sundance and 10 to the drill hole wash.

MR. LEVENSON: And I gather that there have been some more recent samples that confirm the early Sundances, and has there been any recent samples concerning the early high ones of 2,000 meters, especially since the very highest ones were there?

DR. PETERMAN: Not that I am aware, no, according to the reports. The report data, that is the original data, or the early data.

CHAIRMAN HORNBERGER: I just wanted to make sure that we are clear on this now. Milt said that from your 40 samples that you have confirmed high chlorine-36 ratios at the Sundance? That wasn't my understanding.

DR. PETERMAN: No, we haven't. Not in the validation core, we have not.

CHAIRMAN HORNBERGER: I just wanted to make sure that we are clear on that. That the disagreement was the Niche-1 samples; is that right?

DR. CAMPBELL: One last comment here is Mike Ryan's observation of the statistics. Has anybody done an analysis of the statistics of these high chlorine-36, but low chloride samples that are heavily in the bomb-pulse area?

And that is a very curious result to me, and is there an explanation for that? If you look at everything about the 1250 line, most of those samples have much higher air bars, which if I understand the argument about accounting statistics, it is because they have overall very low chloride, and that seems to be a curious result, and possibly an explanation buried in it.

So have you guys pursed that or do you intend to pursue that?

DR. PETERMAN: I guess I am a little dense here. I am not sure that I understand. Does anyone want to -- Leonid, do you want to --

DR. CAMPBELL: The air bars at everything about 1250 on the graph on page 6, the original dataset, that all of the high fluoride Chloride 36 samples appear to have significantly larger air bars associated with them than the stuff below your cut-off point.

And that is a curious result. That is not what I would expect for a natural system, unless you have some sort of explanation for why those samples have a low overall chloride.

I understand the accounting statistics

argument, but from just a phenomenological point, why would the high point 36 samples almost uniformly have relatively low amounts of chloride?

DR. PETERMAN: Now, one could speculate. Perhaps it is a function of -- well, there are a number of factors, such as grain size, and how rubblized the sample might be, and leach time, and all of that.

If you look at the slide on page 28, it sort of shows the same thing, and again that is the low concentration values. I mean, this is the validation core, and that doesn't fit the trend that you were talking about in the early Los Alamos data. The lowest concentration values are all less than five or six hundred.

DR. RYAN: And that point is highly uncertain, and that is a whole different interpretation than if it has got a very small error. So uncertainty analysis has got to be factored in to help with the interpretation I think.

DR. PETERMAN: In addition to analytical uncertainty.

MR. ROBECK: I am not too terribly familiar with the issue of the error bars there, but what I am familiar with is the data in the cross-drift. We don't see a good correlation between fluoride concentration and Chloride 36 ratios, at least in the samples with bomb-pulse.

So we don't necessarily see that the highest Chlorine 36 samples have the lowest chloride. They are kind of just scattered all throughout typical chloride ranges.

DR. RYAN: Now, on distribution to understand in detail, because if you can understand that in detail, you can assess some uncertainty on that basis. And if you don't understand that distribution, or have not figured it out from your data yet, that is something that has to be done.

MR. ROBECK: Agreed. I am looking at the dataset from June, and I am puzzled by the reason for those larger air bars with the higher Chlorine 36 values. One thing that comes to mind, and I just throw this out, as I don't know it is in fact the reason here.

But when I do an analysis, I have uncertainty based on internal accounting statistics. I also have an uncertainty that I will assign based on external reproducibility.

Now, that would generally be a percentage. Now, if that is what June has done here, and simply assigned a five percent uncertainty for reproducibility, that those will appear as larger error bars.

DR. RYAN: Again, the basis for that assignment is critical. If it is just a typical measure error is five percent, that's not going to get it.

MR. ROBECK: That would be your internal error based on accounting statistics. It would be based on external reproducibility of standards.

DR. RYAN: You know, I guess my general reaction to the discussion is without a systematic development of uncertainty analysis in the measurements, and all the components, whether it is instrument uncertainty, sampling uncertainty, contaminant uncertainty, and all those things, you really can't interpret these measurements as effectively as you could with the uncertainty.

You know, simple examples like it took a hundred samples of blanks and what is the average measurement. Theoretically, they should all be the same. Well, if they are not, what is the standard deviation.

I mean, something as simple as that gives meaning to how you sample, and 67 percent of the time, you will be within that. I mean, everybody knows those statistics.

And in fact without that laid out on top of an interpretation, it is hard to ascribe meaning to it.

MR. ROBECK: We have analyzed standards, and along with each set of samples, I will send a few standards, which I know the ratio -- and it is a certified ratio, and those ratios come in very good.

DR. RYAN: That is the part that is not going to come out (off microphone).

MR. ROBECK: Right. And let's just not report it here, but it is reported, or at least it will be reported. But, yes, along with blanks that I typically submit, I submit 10 percent of my samples will be standards, and some of them will be spiked standards, and some of them will be unspiked standards, and those results come out quite good.

So the results are reproducible, at least when we have a nice homogeneous sample, and therein lies the problem. It is hard to envision getting a rock that we could claim is homogeneous that we could process 30 times, and then do statistics on our numbers.

DR. RYAN: Again, that is not what the

blanks, and dupes, and all of that are addressed at -- is a fundamental sampling error that –– you know, I think that relates to the steel plate issue, and some of the other things that you have mentioned.

But again quantifying that systematically is critical. If you have not done that failure repeat sample, you should.

DR. PETERMAN: In terms of the samples, there is really attempts to replicate. You know, it was very difficult to replicate results. So if you were to use those duplicates, in a statistical sense the error bars from those would be off the chart.

MR. ROBECK: And that is exactly what we are talking about, and I think that has been the thrust of the early part of this project. We have been exchanging samples, and we did try to prepare what we thought would be a good reference sample, the Evalve-1 sample, and we performed a number of analyses on that.

And lo and behold, it wasn't homogeneous. It is not a straightforward problem to really say, well, here is a homogeneous rock and analyze it 30 times.

CHAIRMAN HORNBERGER: I think the bottom line is that it is a fairly easy problem if your sample or your analysis cost is $10 a sample. And I think that you are probably not doing exactly what Mike wants because your costs are just a little more.

MR. ROBECK: It would be about 40 or 50 samples a year.

DR. RYAN: I appreciate the difficulty (off-microphone).

CHAIRMAN HORNBERGER: Thanks very much. That was very informative, Zell, and we look forward to hearing about your pass forward, and I do think that I really appreciate Abe's answer, because I do think that it is –- well, I would express my belief that it is critical that we do get to the bottom of this.

We don't want to look at this as a puzzling question mark just sitting out there, and I think we can do it. And I think we will come up with a good plan. Thanks very much. We are going to take a break now, and let's take a 25 minute break.

(Whereupon, at 3:18 p.m., the meeting was recessed, and the meeting was resumed at 3:48 p.m.)

CHAIRMAN HORNBERGER: Okay. I would ask everyone to make sure that they have signed in. We would like to keep a record of who attend our meeting.

We are going to continue our presentations on the DOE scientific update, and we are going to hear some of the results on microbial-induced corrosion, and we have a presentation from Joanne Horn. Joanne.

DR. HORN: I just wanted to first thank the committee for giving me the opportunity to present an overview of our program on assessing the impact of microorganisms on long term nuclear waste containment. I think we are ready for the first slide.

Thanks. Mostly our program has been focused on the effects of microorganisms on the waste package, and these are basically categorized as microbiologically influenced corrosion or MIC.

This is really a complex set of interacting microbial facilitated processes, and it includes acid production by bacteria, as well as iron oxidation and reducing reactions, sulfate generation, with a reduction of sulfate, and hydrogen production.

And also the brown kind of bubble there represents what we call biofilm. All these bacteria are embedded in a matrix of polysaccharide, but it is also generated by bacteria.

And the polysaccharide are long chain sugars that produce a kind of slime. The slime prevents the diffusion of oxygen towards the metal surface, and that also produces conditions that can accelerate corrosion.

Now, which of these reactions occur is really dependent on a number of variables, including the environment. That is, for example, that you can't get sulfide generation without having sulfate present, for example.

Also, the organisms that are present and the material under consideration. Next slide, please. So the goals of this program then are to determine the potential for MIC in the Yucca Mountain repository, and determine the conditions under which MIC would occur, and that includes the boundary conditions for microbial growth since we expected initially will start with a sterile environment, at least on the waste package because of the radiation fields generated by the decay of the waste.

But that eventually we did either a reintroduction of bacteria or a regrowth of those organisms that could survive through that radiation field.

Also, the conditions for microbial activities, and so again that would be -- you know, you have to have the necessary sulfates for a given end-product to be generated.

And also the quantified rates of MIC on

the waste package materials, and that would include the production of dilatory and metabolic end products, and also the direct effects on candidate waste package materials. Next slide, please.

Okay. So we have taken this kind of multi-prong approach to answering these questions, and among them ethological studies, and we are looking at the types of organisms that are present, and expected, and that would essentially establish the potential for MIC.

The conditions under which microbial growth would occur, and if you couple that with some of the thermal hydrological testing, for example, you could estimate the time that the MIC might initiate, and that will become clearer on later slides we think.

Looking at the effects of microbial activity on water composition, and so that would be a kind of indirect effect of bacteria or fungi. For example, if they were to acidify the ground water, and then the ground water impacted the waste package.

We need more traditional electrochemical studies to quantify the overall changes and corrosion rates due to MIC, and these studies can also indicate the mechanism by which this acceleration occurs.

We are performing accelerated testing as well, using both mixed cultures, and that is the entire Yucca Mountain community, as well as using pure cultures with defined microbial activities.

And in these studies we are looking at the survecial effects of the materials, and the biochemical effects on water chemistry, and the pure culture studies can provide boundary conditions, and for example, the generation of these deleterious end products. Next slide.

Okay. So first I would just like to just address the ecological studies and we are doing a characterization of the Yucca Mountain microbial and fungi communities, using a number of different methods, and we have also determined what the extant microbial densities in the mountain are, and the growth limiting factors. Next slide, please.

Okay. We started these studies a number of years ago by simply isolating microorganisms from rock that was excavated aseptically from the mountain. This is within the ESF.

And also from the large file test, and what you are seeing on the left there -- and I don't have a pointer, and so I'm sorry. Oh, do we have a pointer in the audience? Wonderful. My hero.

Perfect. So what you said, hopefully it

won't blind you in the process. On the left, you will see -- or laser paint you. Okay. Those are little bits of rock that we actually collected from the repository, aseptically crushed them and aseptically, and what you see there are bacterial colonies growing right out of that.

And those are criteria that are contained on the surface of the rock, and each one of those colonies rises presumably from a single cell. On the left, again, you see bacterial colonies, and those are from actually artificial poured water formulation that we washed this rock with, and then plated that out, and these are all on low nutrient media.

And so you can see that there are indeed bacteria that are contained within the mountain. Next slide, please.

Okay. What we did initially was to first isolate these bacteria, and speciate them, and then we tested them for a number of activities that were associated with corrosion, and found that indeed many of these had these activities.

And so were thereby established the potential for MIC to occur. Next slide, please. We also determined what the bacterial densities in the mountain are, and we did this not by using growth, but by directly extracting fossil lipid fatty acids, which are membrane components, directly from a rock core.

What we did was that we drilled the rock core out of the ESF, and split it in two, and one representing the sort of region that was closest to the drip wall, and one that was further into the wall, and we found that there was some difference in fossil lipid content.

You can estimate the number of bacteria here by normalizing the extracted fossil lipid to that from a known number of bacteria, and you can see that there was some difference between the surface and the at-depth cores.

But the bottom line was that it was about 10 to the 4th, or 10 to the 5^{th} bacteria per gram of dry rock. The next slide.

Okay. We have also done a number of growth studies. This is a graph, and we are looking now just at crushed rock from the site, and amended with –- this is assimilated ground water at 1-X concentration, with or without glucose.

And looking at the growth of bacteria from the rock over time, and what you see is that as soon as you add ground water, you get a significant increase in the numbers of bacteria that you can recover in the acetous phase, up to or from 10 to the 6^{th} bacteria, and approximately without glucose added, or up to 10 to the 8^{th} with glucose.

So this showed us that the major limiting factor to growth was water availability. And as soon as you add water, you are going to get a significant amount of bacterial growth.

And we have also done other studies that I didn't think I would have time to show here, and so I just mention them here. We have also established that phosphate is the major nutrient limiting factor in the mountain, and that if you actually add phosphate back to these systems, you get an increase on the order of one to two orders of magnitude. And carbon is well as this slide shows.

There is apparently enough sulfate and nitrate in the mountain to support growth, even in 1-X ground water. Next slide, please. Now, this is important because it tells us when the possible kind of on-switch for bacterial effects would occur during a repository revolution.

And I just want to apologize here for the slide. I think we lost a little in the transport of these slides from Livermore to here, but on the left is relative humidity, and this is actually down from

Tom Bucheff's modeling group at Livermore, the thermal hydrology.

And what we are looking at is the relative humidity on the rock walls over time after closure. Okay. So this would be after ventilation is shut off, and what we see here is that it areas of low infiltration, the dose of humidity never increase over 70 percent.

But in areas of higher infiltration and I think that is about 50 millimeters per year, you almost maintain a hundred percent humidity on the rock walls.

So knowing that water is a major limiting factor for growth, we could see that in areas of high infiltration, you will have growth supported almost immediately after closure.

Whereas, in areas of low infiltration, you may never reach the humidity's that are required for growth, and actually in the models we have put the cut-off for bacterial growth at 90 percent humidity, which is probably conservative.

The literature is more on the order of 95 percent. Okay. Next slide.

CHAIRMAN HORNBERGER: Joanne, can I --

DR. HORN: Sure.

CHAIRMAN HORNBERGER: Going back to your previous slide, where you concluded that water is the major limiting factor, what are they growing on? I assume that these are aerobic experiments?

DR. HORN: Yes. These are aerobic experiments.

CHAIRMAN HORNBERGER: And what is the energy source?

DR. HORN: You know, we -- I don't know whether it is dead cells, and if you look in the literature, there is some evidence in the deed subsurface, things like organic carbon being a possible source.

Some of these organisms do fix CO2, and so not all of them need an organic carbon source. You know, we have isolated all the bacteria that we could out of those experiments, and indeed we have found some CO2 fixers.

MS. TREICHEL: What is the numbers on the bottom?

DR. HORN: Maybe we should –- oh, I'm sorry, on this slide?

MS. TREICHEL: Yes.

DR. HORN: I think it starts at 150 years, because I think that's when closure starts. And I think those are a hundred year increments.

MS. TREICHEL: And 450 and –

DR. HORN: Right.

MR. LEVENSON: Joanne, on your slide that George just asked about, where you have the sterile control. What was the water and glucose, or what was the sterile control with water, and with glucose, or without glucose?

DR. HORN: The sterile control actually simply contains rock that was sterilized. What we do to sterilize the rock is that it is actually fairly typical to sterile Yucca Mountain rock.

We have tried autoclave emitter periodically and that doesn't work. We use a gamma or a cobalt-60 source, and we eradiate it for about at least three mega-reds.

MR. LEVENSON: And what was the media? Was it in water or in ––

DR. HORN: Yes. It was, and so you then have to sterilize rock or non-sterilize rock, and we added a formulation that approximated Delaney's formulation for J-13.

I can show you that. I actually brought some extra overheads. You know, I apologize, because I thought that I would have a little less time than I did. So I kind of eliminated some things. But if you are interested -- well, okay, next slide please.

Okay. When you grow organisms from any environmental sample for that matter, you only recover about one percent of those organisms that are present. So to overcome that, there has been methods developed to directly extracting DNA from environmental materials, and they characterize in the organisms by sequencing the DNA that has been extracted.

And we have actually done a study on Yucca Mountain rock, so that we kind of like brought out a stone, and we got DNA out of rock. It took about half a kilo of rock to extract a sufficient amount, but we were able through various biochemical and genetic manipulations to separate these DNAs, and to take the unique ones, and have them sequenced.

And what this is, is to follow the genetic or evolutionary tree of the organisms that we were able to identify, using this DNA analysis. And we recovered about -- well, we identified about 65 different organisms.

And you can see that they stand out -- these are actually about 45 of them, and we have 20 of them that we still need to actually insert into the tree.

And then you can see that they span over a broad and follow a genetic range, and they include these high GC gram-positive organisms that are typically found in betas one areas, and they are very resistant to desiccation, and a number of other organisms.

These proteobacteria are very metabolically diverse, and a lot of them produce acids, and have different metabolisms that are in fact associated with corrosion.

So this is really meant to give us a kind of baseline, although the repository is expected to be an open system and so anything that we presume is going to be able to invade and get in there. But at least we will know what we are starting off with.

And if we associate the metabolic activities with their ability to produce corrosion of these various groups of bacteria, we may be able to get a handle on at least what we will be dealing with. Next slide, please.

We also looked at or identified a number of different fungi and we have identified these. These were actually obtained by slotting and just growing and isolating various bacteria from a region of the ESF where there ventilation had been shut off.

And so fungi are important or potentially important because they produce organic acids, and the waste package materials could be susceptible to these production of bioorganic acids. Next slide, please.

We also have done some experiments or we are actually in the process of doing these now, but we have a long-term corrosion experiment that is going on at Livermore, and this is depicted here. This is a picture of the facility.

Each one of these tanks is about a thousand liters and they contain -- they are actually environments that mimic the expected repository environment over time.

They vary in ironic strength, and temperature, and pH, and although no bacteria was introduced intentionally into these tanks initially, we had preliminary evidence that at least some of the tanks had been at least somewhat colonized.

But what is interesting to us about this is that it sort of reflects the repository evolution. That is, that you start off with a fairly sterile environment, and then kind of anything that is wrong that can survive in there will do so.

And so we thought that it would be a good thing to test these tanks and analogously determine what the microbial sort of roster of organisms is in there to see what may fly into the repository and survive.

Okay. Next slide. So this is the results from one of these tanks. This is a tank that contains water that is meant to mimic dilute ground water at 60 degrees, and it contains the corrosion resistant materials like Alloy-22.

And we found five different groups of organisms I should say, and we actually had an organism that is radiation resistant interestingly enough, and we also found one that was heat tolerant, and then the bacilli, there were five different bacilli that we isolated that were identified that were actually all sporulating organisms that came in with both desiccation and high temperature.

And we are analyzing another tank now that is acidified water at 60 degrees, and from that we have observed a very strong DNA signal, and we have cloned, or amplified and cloned the DNA, and we are screening them now to determine which organisms are present.

MR. LEVENSON: Joanne, excuse me, but on your slide that shows the facility, does the tank environments mimic expected repository environments?

These tanks all have liquid phases?

DR. HORN: They both -- actually they are half full, and so they have half of the samples of the corrosion coupons are actually submerged and then half of them are in the vapor phase.

MR. LEVENSON: It may be that a possible repository environment would be better than expected. It is full of water.

DR. HORN: Right. This is true. I guess mostly the chemistry was what we were most concerned about when devising the environment that was being tested. But thanks, Milt, you're right. Next slide.

So just a summary then of some of these ecological growth studies. We know that microorganisms are extant in Yucca Mountain rock, to the density of about 10 to the 4^{th}, to 10 to the 5^{th} bacteria per gram.

There is also a wide variety of fungi, and the major growth limiting factor appears to be water, and when water becomes available, we will expect that microbial growth will ensue.

That also we are expecting that infiltrating water will likely transport organisms into the repository, and cultured Yucca Mountain bacteria have activities associated with MIC, and this establishes a potential for MIC in the repository.

That uncultured identified organisms span a wide phylogenetic range, and their activities are being investigated for MIC activities. In the investigations of the corrosion test tanks, show that organisms adapted to repository environments will become established.

Okay. Next slide. So I would like to move on then to electrochemical studies that we have conducted to quantify the overall contribution of microorganisms to corrosion, and then these types of studies also offer an indication of the mechanism of biogenic alterations to corrosion rates. Next slide.

So primarily for the studies thus far, we have used a test cell that we have actually devised at Livermore and this is composed of -- on the bottom of this working coupon is the material that is being tested, and it forms the base of the vessel.

And we either cook these with Yucca Mountain microorganisms that we have isolated and characterized, or we leave it sterile. So we consistently try to run our experiments under both sterile and non-sterile conditions to determine what the biotic effects are. So you can subtract out all the biotic effects.

And the media that we have used in these experiments again thus far is a fairly rich media and sort of accelerated the whole process and produced microbial growth.

And into this we have a platinum electrode that is attached actually to potentiasac (phonetic), and under an applied current, you can build up a potential on this coupon and compare it to that of a reference electrode, and it turns out that the corrosion potential or the potential build-up is directly correlated to corrosion rates.

So this is a means of actually measuring corrosion rates in real time. Okay. The next slide. So we incubate these for a period of -- in this case up to about five mines, and this is looking at –- and, you know, I apologize, because when they reproduced these overheads in black and white, I think you lost like the green like the green and the red, and you can't decipher.

But what this depicts is one of these linear polarization studies with either carbon steel, or Alloy-400, which is a copper nickel alloy. You can see that under sterile conditions this is the Alloy-400, a fairly corrosion resistant material.

Notice here that corrosion rates and

microns per year are on a log scale, and so you have very low corrosion rates under sterile conditions. And yet when you add the bacteria, and that is the red circles, and they appear, you can see that you have increased corrosion rates on the order of 200-fold.

Similarly, with carbon steel, under sterile controls, and that is the yellow squares, you have a lower corrosion rate, albeit it's on the order of one micron per year.

And it increases to about 8-fold, or I think it is about 6-to-8-fold actually when you add bacteria to the system. So in this way we are able to actually establish what we call an MIC factor, or that factor by which microorganisms increase the corrosion rate of a given material.

And in this case, it increases the rates of Alloy-400 almost to sterile, the level of the sterile carbon steel. Next slide, please.

Okay. This is the same type of study, and this time we are looking at probably most interestingly Alloy-22 and stainless steel 304, as well as I625, and what you see is the Alloy-22 under sterile conditions, and non-sterile.

And you will notice here on the Y-access that these corrosion rates are much lower than that of the Alloy-22, or I'm sorry, the Alloy-400 or carbon steel. This being one of the reasons that we are using Alloy 22, or not using it, but promoting it as a possible candidate material for the corrosion resistant barrier of the waste package.

And the bacteria, at least in this experiment, don't appear to have that much of an effect. I mean, they raise it by the order of two-fold, and they have actually incorporated that MIC factor into the current models, and the next slide -- oh, I'm sorry.

So at the termination of these experiments, we did what was called an anodic polarization test, and what this shows is three of these materials, and again a sterile control, and inoculated with Yucca Mountain bacteria.

And you can see that under a given potential here that there is always a higher current density with the Yucca Mountain bacteria, and this is fairly consistent for altering materials.

This actually shows that the mechanism by which these bacteria are causing these increased corrosion rates is by accelerating the anodic reaction or the dissolution of metal.

So we think that is how they are working, and we are investigating that further. The next slide is sort of a summation of the status. Again, for example, the carbon steel, these are average corrosion rates, and so what we have done is just under steady state averaged all those points.

Again, a factor of about 6 or 7-fold under sterile conditions, versus non-sterile, and then again for Alloy-22, only by a two-fold difference.

Now, this may be somewhat of an under-estimate of corrosion rates, because if you recall when I showed you the set-up of this experiment, it is actually run under batch conditions for about five months, and although we have not measured the oxygen concentrations, we think they are going anaerobic. That would be fairly typical. They are not being mixed or aerated.

And so we would expect that they would be depressed or the overall corrosion rates. Now, the actual MIC factor or ratio of sterile to non-sterile may remain the same. But we are checking that out by running these experiments under aerated conditions presently. Okay. Next slide.

I don't want to make too much of this, because this is a very preliminary result, but what we did was to test at the termination when we tore down some of these experiments what the soluablized concentration of alloy elements were in solution to see if we could get any idea of how fast the metal was going away, or which alloy elements might appear.

And what we saw in the case of Alloy-22 was that when it was sterile, we couldn't detect either nickel or chrome in solutions, but when we added the bacteria, we detected a noticeable amount of chrome. This is in parts per million.

Now, this isn't to say that we are actually getting selected dissolution of alloy elements. It may be that everything does go away at the same time, but that some of the alloy elements reprecipitate.

So I don't want to make too much of this, but what we are doing now is to -- that instead of looking at what is left in the solution, we are looking at what is left on the coupon, okay? And that is a much better measure, using sputtering x-ray photoelectron spectrostrophy, we can actually determine what the ratio of alloy elements is as we sputter into the metal on a very high resolution.

So it is a much better measure of what is going on with the mode of dissolution here. Okay. Next slide.

So to summarize then these electrochemical and dissolution studies, carbon steel shows an increase in corrosion rates for the Yucca Mountain bacteria and Monel shows even a greater MIC factor.

The Alloy 22 shows a lower increase in MIC factor, only two-fold so far, and delineated MIC factors require further investigations under more representative, i.e., aerobic conditions.

And this is another aspect that I neglected to mention, was that when you polarization this, normally you use to measure a generalized rates of corrosion, and MIC is usually characterized by what is called a localized effect.

That is, it is more associated with pitting and so forth. Now a better way to assess that is using cyclic polarizations. So what we are doing now, is that we have got some testing planned to better estimate these localized corrosion effects.

Okay. To date, the anodic polarization analyses demonstrate that microbes are causing an increase in anodic activity; that is, metal dissolution.

And that the MIC factors thus far determined have been incorporated into a role model. The next slide. Okay. Let me move on to our accelerated materials testing program, and we are actually doing three different types of testing for this.

We have got a simulated saturated repository environment that we call microcosm for obvious reasons, although Milt may disagree, and then we are doing peer culture studies and using organisms with defined microbial activities.

And we are also doing some batch chemical testing. So I will describe each one of these. Next slide. These are simulated saturated repository microcosms. They are fairly simple systems, but they include what we expect would be all the elements of a saturated repository.

So what we do is we feed the actual microcosm environment with a formulation that is ten-fold concentration of J13 ground water. We supplement it with some glucose to accelerate the process, the microbial growth, and we feed this at a very slow rate, at about 2 mils an hour, into this vessel, which contains aseptically collected and crushed rock.

And again we run these under both sterile and non-sterile conditions. Again, sterile controls are produced by eradiating the rock at 3 mega rads. And into this we also put candidate material coupons of waste package materials.

So that periodically we can withdraw the coupons and look at the surfacial effects of the bacterium. Next slide. This is just a picture of what some of these microcosms setups look at. This is the reservoirs, and these are being incubated at 30 degrees C.

We were running them presently at 30 and at room temperature, and it goes through a pump into the microcosms and out through a pump and into a waste reservoir. Next slide.

And one of the things that we have been able to do is that we when we withdraw coupons, we look at them first just under fixed, and we fix them with either glutaalgahyde (phonetic) or we approximate a critical point fixing.

But if corrosion products are evident, we can image them using scanning electronscopy. And then in this case it is carbon steel, and so the corrosion products build up rather quickly and these are just different mil basis that we have been able to identify through facial chemical effects. Next slide.

An in fact this is just looking at the SEM, and we can identify the morphology of these corrosion products, and we are using the EDS, and we can identify their elemental makeup, and we have been able to do x-ray refraction and actually identify the mineral phases.

So we can match these up, and pretty much not only identify the mineral phases, but what likely they originate from. For example, the silica in this case comes from the rock that we have incorporated into the system. Next slide.

Now, despite the fact that these systems are being fed continuously, and you are continuously getting a dilution of whatever chemical effects are occurring in that microcosm.

And you are also washing out any of the chemical alterations. We have been able to detect and I don't want to make too much of this either, because you are looking at parts per billion here, but this molybdenum in the efflux, that is, in the angelus phase of a microcosm containing Alloy 22, and under non-sterile conditions at 30 degrees.

And we really are not seeing the same thing with the sterile controls or the new metal controls, or even the non-sterile at room temperature. But again we are investigating this further. Next slide.

Okay. When we withdraw these coupons, as

I said, first we fix them and image them, and then we clean them. And we use high resolution imaging techniques and in this case atomic force microscopy, to look at the surface and to see if we can discern any differences due to the presence of bacteria in the rock.

And here you see that this is what we start off with. The surface was sanded to 600 grid initially, and so it is fairly rough, and that is what these striations are. Again, I want to emphasize that you are looking at a very small piece of property here. This is a hundred-square microns, okay?

And the Z-axis is 3 or 3-1/2 microns, okay? So it is a very high resolution. The sterile controls for microcosms containing just the sterilized rock, you see a kind of flattening of the striations.

And in the non-sterile coupons, these are all incubated for a year, and the non-sterile coupon, you can see that there appears to be a kind of redistribution of the roughness, and it may be something like nano to micropitting. The problem here I think with this analysis is you are starting with a rough surface, and you are ending with a rough surface.

So it is pretty darn difficult to get your arms around quantitatively around what is happening. So what we are doing now to remedy that situation is to incubate mirror finish coupons. So that means that we start with a much flatter surface, and if we see it erupting, we can at least quantify it.

Next slide. Okay. This is looking at a non-sterile coupon of Alloy-22 going through two years in a non-sterile microcosm, and 1 year or 1-1/2 years, 2 years. So again there does seem to be some effect, but they are small.

Again, the Z-axis is 3 microns, but they are clearly not rare events. I mean, we can zero in on these regions without too much difficulty. But we need to get a better handle on the distribution of these events as well. Next slide.

So to summarize the microcosm experiments then, we have got a system that allows analysis of material effects in an environment that includes essential elements of a repository. That the effects of the microorganisms can be discerned by comparison with a biotic controls. And we also have no metal controls, and so we can look at the effects of the rock top.

We have combined chemical, analytical, and imaging techniques to quantify specie and corrosion products. We also do gravimetric analysis of these materials, which permits the estimation of corrosion rates and effects.

And there appears to be some nano effects of microbial activity on Alloy 22, but quantification and distribution of corrosion needs to be analyzed with mirror finish coupons, and then the results can be incorporated into the corrosion models.

Next slide. So we are also doing some pure culture work, and what I did was to go through a kind of systematic analysis of Alloy-22 and titanium primarily may most likely be susceptible to microbial corrosion.

And what I came up with is -- and then what we did was to pick organisms that have these specific activities, and grow them in peer culture. So this is what we call a microbiology continuous culture.

So you are constantly feeding the bacteria, and grow them under optimal growth conditions, okay? So what we are doing is producing this very vigorous high-density culture, and then we picked these specific bacterium. Clostridium produces hydrogen at point high rates.

And in order to see if they generate

hydrogen embrittlement, and we are also testing a sulfate reducing bacteria that produces sulfide, and it also happens to grow in high salt environment.

We are looking at a thiobacillus organism that generates sulfuric acid when grown in reduced sulfur medium, and we also are taking a mixture of Yucca Mountain fungi that we isolated, and we are growing that in some rich broth to see if the generation of organic acids is going to affect corrosion of these materials. The next slide.

So this is the microcosms, except that now we have just -- we don't have any rock in these studies, but rather we have these defined organisms in separate experiments, and they are being fed with media that is conducive to generating these possibly deleterious end products, and in the reactors we have got trays, Teflon trays containing both titanium Grade 7 and Alloy 22.

And of course they are being drained at the same rate that they are being fed at. The next slide.

This is just a picture of a c. acetobutylicum bioreactor. It is about a one liter vessel, and this is actually contained in the anaerobic glove box, because these are anaerobic organisms that are grown in an nitrogen atmosphere. Next slide.

Okay. This is a picture or an SEM image I should say of the biofilm formation on a titanium coupon in a sulfate reducing bioreactor. And you can see that on the little rods here that they are microorganisms. They are colonizing the surface, and on the right this is actually a picture of or an image of that polysaccharide matrix that I mentioned earlier.

And you have to of course dry the samples, fix and dry them in order to see them in the SEM, and so when you dry them, the film tends to crack them, and that is what you are seeing there. But it is definitely evident and present. And the next slide.

So this is the sulfuric acid producing culture, and after seven months we withdrew some of the coupons, and surprisingly we actually found some dissolution of titanium from the surface.

This is again what we started with, AFM images again. This is in a sterile control and that is just incubated in a bisulfate medium. And it looks fairly degraded when we looked at the same, or the one that was exposed to culture.

And we actually found that we precipitated the titanium in the reactor, and the increasing roughing was also confirmed by doing what is called a root mean square analysis. Root mean squares are an index of surface roughness, and you can see here with the titanium that you actually increase the surface roughness.

But fortunately with the Alloy-22 that it didn't seem to have any effect. So that was a good thing. But this isn't actually the first report of MIC of titanium. People have looked for it for a long time, but they never used quite these conditions. The next slide.

So the summary of our pure culture studies so far is that we can analyze the effects of specific deleterious metabolic products on material performance, and it permits the determination of the upper limits of generation of these end products.

We are actually establishing that now, and we are doing things like measuring the organic acid concentrations of several organic acids, including those that have been recently found by the USGS in pour water form the site.

And it establishes some kind of upper bound so that we can incorporate those into models for the production of these end-products. And despite the fact that there is a continual input and output into the system, a steady date is gained, and I didn't really show this slide, but we have been able to see, for example, titanium dissolution again in our clostridium CW2 reactor.

So we can actually see a surfacial analysis of the material coupons is now ongoing. Okay. The next slide. I just lastly wanted to mention a set of experiments that we have just recently initiated, and I wanted to get past this dissolution and washing sort of issue that is connected with continual flow systems.

What we have done is to start some experiments under batch conditions so that we can look at the build up or accumulation of either alloy elements if they are being soluablized or of the metabolic or alterations to ground water that the microorganisms are generating.

And so in these experiments, we are using crushed tuff and our simulated J-13 ground water, and we can use either anaerobic or aerobic atmospheres.

And we think that we are actually using Alloy-22 foil and the reason that we are doing that is to sort of increase the surface area and the mass ratio. So that if these materials are actually being corroded, we can detect them more readily by just having more surface area being exposed in the experiment.

And we can -- and, of course, we always run our sterile controls with or without organisms. We are also running with them without a carbon source. And we are analyzing periodically the generation of sulfide acids with a waste package alloy elements.

So it is sort of looking at all these different alloytes so that we can get a better picture of what the change in chemistry is both for the alloy that we are testing, as well as the ground water. The next slide.

So just to summarize overall then of our MIC studies to date, we are looking at the potential for MIC to occur, and that has been affirmatively determined.

We are looking at the conditions for microbial growth, which have been established, and then coupled with thermo hydrological modeling, and this establishes when MIC may become a factor for microbial effects.

We have generated a roster of organisms extant at the Yucca Mountain site and also organisms that may colonize the repository. And then if we --

and answering that why question, coupled with their associated metabolic activities, this information will allow what MIC activities may be relevant to waste package corrosion.

And initial MIC factors have been determined, and establishing the overall contribution of microorganisms to waste package corrosion, and we are doing further testing on that, and under other conditions.

Our dissolution rates and corrosion modes of engineered barrier materials are being determined, and the upper limits of deleterious bacterial end products and their effects on these materials are being established.

And lastly the effects of the Yucca Mountain groundwater are currently under investigation. So with that, I will conclude my presentation and invite any questions from the panel.

CHAIRMAN HORNBERGER: Thank you, Joanne. Milt, as our MIC expert, would you like to go first? Well, Ray, do you have any questions?

VICE CHAIRMAN WYMER: First, let me say that it looks like a very nice work, and it is a lot more than I have seen up to this time, and you are to be congratulated on the scope of your studies, because they are very broad in trying to cover all the parameters of interest.

DR. HORN: Thank you.

VICE CHAIRMAN WYMER: I do have some questions that you probably have not had enough time to do research on to answer yet, but let me go ahead and fire away.

First, I wondered about the potential rate of bacteria entering the repository by whatever route that they enter over a long period of time, and whether there is enough there that it makes any difference.

DR. HORN: Well, you know, it doesn't take very much to start with to generate a lot, because they divide by binary fusion. So they grow at an incredibly high rate if the conditions are right.

VICE CHAIRMAN WYNER: If the nutrients are there?

DR. HORN: Yes, and I think –– well, pretty much the assumption is at this point in the field is that organisms in the deep subsurface primarily are -- and they either originate when the rock was laid down, or they infiltrate with incoming ground water.

So in this case, we would be looking at

infiltrations. So I think that the number of microorganisms that come in absent ventilation, but that is another issue, will be primarily dependent upon infiltration items.

VICE CHAIRMAN WYMER: And I suppose the nutrients have to come in with them?

DR. HORN: Yes, except that so far we have found that they don't need very much to grow. If we give them ground water, even unamated within a carbon source, that they appear to be able to pick up and grow fairly readily.

VICE CHAIRMAN WYMER: Of course, they all need a phosphate backbone, and so --

DR. HORN: That's true, that is an essential element. Now, there is a about 200 ppm phosphate in the rock, which I am sure that many of you are aware of. And when we don't put -- and I didn't show these experiments, but when you don't add phosphate to rock, we are presuming that the phosphate that they are growing on, they are dissolving from rock. And there is actually a good deal of evidence in the literature to suggest that bacteria can readily dissolve phosphate from the rock.

VICE CHAIRMAN WYMER: Okay. There is a question of the mixtures of the bacteria comes up, and you did studies with typical Yucca Mountain mixtures of bacteria.

DR. HORN: Right.

VICE CHAIRMAN WYMER: But then you are doing the peer culture studies, too.

DR. HORN: Right.

VICE CHAIRMAN WYMER: It looks to me like some of these bacteria would be fighting each other, and they are reducing bacteria, and they are oxidizing bacteria.

DR. HORN: Yes. Yes. And that occurs in subsurface environments. As an example, there are methane producing bacteria that attack CO2 and reduce it to methane, and then there are methane oxidizing bacteria that use the methane as a carbon source and generate CO2. So, analogously, you know, manganese oxidizers.

VICE CHAIRMAN WYMER: And in the repository the question is who wins?

DR. HORN: Well, actually, in this case I don't really think that they are fighting each other, because in a way they are really facilitating each other's physiology. In other words, if you are a manganese oxidizer, you need reduced manganese, and so if you have a manganese reducer that is producing that as an energy source for the manganese oxidizer, that guy kind of has it made.

So I think in some sense that if you look at the overall storic-metrics, as a chemist, I can understand how you think. But from a microorganisms point of view, this is a good thing, because you have got available sub-stain.

VICE CHAIRMAN WYMER: And you have, for example, that you are either making sulfite, or you are making sulfate?

DR. HORN: Right.

VICE CHAIRMAN WYMER: You are not making both of them.

DR. HORN: Yes, the sulfite oxidizing bacteria are actually anaerobic. And ultimately these things are striated according to their environmental micro-niche.

So, for example, the sulfite generating bacteria are anaerobic. And then you see this, for example, in sediments in marine sediments, where you have a lot of sulfate and sea water, and you have got a lot of sulfate generating bacteria in sea water. But you get right into the sediment and then you get very anaerobic. You only have to get down a couple of millimeters and then you get sulfite generation.

VICE CHAIRMAN WYMER: In a waste package, you are probably going to have one or the other.

DR. HORN: Well, in even that, in these binner films, you have very diverse microenvironments. So, for example, at the top, you can have an oxidizing environment, and then the oxygen concentration pops precipitously as you go towards a metal surface.

And so you can have these sort of micro-niches, where things that have very diverse physiologies can actually exist side by side. So I know that it is sort of counter-intuitive, but apparently that has been shown.

VICE CHAIRMAN WYMER: Actually, I have argued in the past for reducing environment, and what is the repository in localized areas which supports the oxidation.

DR. HORN: Yes, and from a micro logical point of view, everything runs slower under anaerobic conditions. You just don't get as much energy out of the anaerobic metabolism. And so from that point of view, I think an anaerobic reducing environment is sort of better.

VICE CHAIRMAN WYMER: Now, what about temperature effects? How do these --

DR. HORN: Sure, superimpose them.

VICE CHAIRMAN WYNER: Are you planning experiments at several temperatures?

DR. HORN: Yes, we found some sort of crude kind of –- well, just kind of under anaerobic conditions moving the temperature up. We have not found much growth after about 60 degrees, but just the organisms that are extant in the rock.

Of course, we know that there are organisms --you know, those that grow in hot springs and down in the smoken vents in the deep sea that can exist up to temperatures -- I think about the upper limit for life is about 120 degrees C.

We are not sure whether we are seeing any of those organisms. So far we haven't found any. We are still at the beginning of testing the tanks, and that is one of the reasons that I think those test environments are going to be really interesting to see, and if there are any floating around, are they going to become established there.

Because the canonical thought in environmental biology is that things will grow and become established if they are adaptive to a particular environment.

So it is not totally beyond the realm of possibility that we will see these things growing and

--

VICE CHAIRMAN WYMER: And it could be quite a while before the surface of the waste package will get down to 60 degrees or 70 degrees.

DR. HORN: And even more than temperature, I think it is going to be water availability, because we know that there are things that can grow at high temperature. But water availabilities -- I mean, life needs water, and that is the bottom line.

And so we really are not expecting microbial growth until water reenters the repository, but the water availability is tied directly to the temperature of radiation. So as the temperature drops, water increases, and radiation drops.

So those three factors are really tied together, but since water seems to be the primary riveting factor, we have kind of picked on that as the kind of switch.

VICE CHAIRMAN WYNER: And on the waste package, you do have both temperature and radiation fighting you pretty good?

DR. HORN: Right. Absolutely, and those things will prevent the growth directly on the waste package for thank god a good long length of time.

VICE CHAIRMAN WYMER: John Garrick has

given me permission to ask his so what question.

DR. HORN: Yes, so what, and I was expecting that.

VICE CHAIRMAN WYNER: Just take your general corrosion rates from one of your viewgraphs, and you come up with maybe for the Alloy-22 a couple of millimeters in 10,000 years, and for stainless steel, 3 or 4, or maybe twice that.

DR. HORN: Right.

VICE CHAIRMAN WYMER: Maybe for 3 or 4 millimeters, maybe 10,000 years.

DR. HORN: Right.

VICE CHAIRMAN WYMER: That doesn't get through the waste package. So let me ask you what is your opinion about the significance of the microbial on the waste package?

DR. HORN: Well, you know, I mean, we didn't design these experiments to prove that bacteria were going to be a problem. We designed them to answer that question will they be a problem.

So I think under the conditions of this particular experiment, we have shown that it won't be a problem, which is a good thing. Now, like I said, these may be depressed somewhat because of the conditions under which we ran these experiments, and that's why we are repeating them.

And we are also doing some alternative types of testing that are better at looking at sort of localized pitting, which is what bacteria are really known to do.

VICE CHAIRMAN WYMER: Well, thank you very much. That is really nice work.

DR. HORN: Thank you.

DR. GARRICK: Just continuing with that a little bit. I am curious about how much microbial corrosion you would have to have in order for that as a waste package integrity threatening mechanism to be competitive with, for example, the current corrosion model, which is a diffusive transport model that eventually leads to intergranular corrosion cracks in the absence of water, and only in the presence of an assumption about a film.

So there is no water until the drip shield begins to fail, which according to the current model doesn't occur for several tens of thousands of years.

So what is the relevance of all of that? If you have already got a failed waste package in the absence of water, how can we become concerned about a contribution that comes from a phenomena that has to be in the presence of water?

DR. HORN: So you mean that you can't kill it twice?

DR. GARRICK: Yes.

DR. HORN: You know, I might just defer to one of my colleagues who has more familiarity with some of the other modes of corrosion. Dan McCrite has been in the program for a long time, and Dan, do you want to give that one a crack?

MR. MCCRITE: Well, one of our major concerns with the MIC factor is what it would do to localized corrosion, and possibly stress-corrosion cracking, again in an anaeceous setting, because in those cases the MIC factor would be a lot more than just two. It would be in the thousands.

And that is analogous to some of the industrial or field studies that components have failed by MIC components, particularly the stainless types of materials, like stainless steel and so forth.

But when MIC is a significant factor in your corrosion, it is usually in a crevice or around the weld. And today we have not studied all those things with MIC as also a component. We have done a lot of testing in just purely a biotic condition, but we plan to also do those same kinds of studies with MIC components.

It is a little harder test to do because obviously we have to keep the microbes alive during the duration of the experiment. So also have had some problems in getting suitable samples, especially welding samples, where we will carry those experiments out.

So the data has been essentially the effect of MIC on general corrosion, which really isn't much of a major problem with Alloy C-22, whether it is biotic or a biotic. But we think that if there is an effect that that it is going to be in localized corrosion and stress corrosion cracking, and those experiments remain to be done, particularly with MIC as a component.

DR. HORN: And just to add a little bit to that, is that it has been established that microorganisms really like weldments, and so we are pretty anxious do these same experiments and look at the differential effects on weldments.

DR. GARRICK: Many years ago, when the WHIP project was going through a stage similar to what the Yucca Mount Project is going through now, one of the big worries was gas generation.

And one of the big anxieties about gas generation, at least in the early days, was microbial induced corrosion on the drugs, et cetera, et cetera.

Eventually that issue seemed to go away, and the experts on microbial corrosion came forward and essentially indicated that this was not a real issue.

Is the information that led to that conclusion or the technology that was associated with that effort -- and I realize that geology is very different, and the materials are very different, except for iron. But has that information been a part of your --

DR. HORN: You know, we have not worried about it too much, because we really have an open system here. I mean, are you talking about within waste packages?

DR. GARRICK: Yes.

DR. HORN: Well, I am not too worried about within waste packages, because I think everything is just going to be killed there, and the wooden facility, since it is a low level radiation environment, they were much more susceptible I think.

So once bacteria can recolonize the inside of a waste package, it has already been breached, and so already you have defined an open system. And we know that it is not like in the Canadian version or their design.

It is a very tightly packed system. I know that they are also worried about gas generation and pressure buildup, but I think the inside of the packages are going to be sterile. If anything ever gets in there to recolonize, by definition it has to be breached.

So you don't have to worry about pressure build up on the inside of the cans. And then on the exterior of the packages, I don't think we have to worry about pressure buildup, because we essentially have a breathing open system.

DR. GARRICK: I wasn't thinking of it so much as having to worry about pressure buildup. I was more thinking about it at the mechanistic level, and the mechanisms.

DR. HORN: Well, we have this one experiment going right now, and I guess hydrogen embrittlement is more of a concern for titanium, and so we have got this hydrogen producing culture that generates hydrogen like nobody's business.

And so we are actually testing whether we can induce hydrogen embrittlement by these organisms.

It is kind of a worse-case scenario, and then looking at the mechanical effects, and we will be doing the same on the surface to see if there is actual hydrogen invasion as a result of microbial generation of hydrogen.

So from the literature is real ambiguous on this topic. Nobody has ever definitely seen MIC induced hydrogen embrittlement.

DR. GARRICK: And just a final comment. While you are doing these experiments are you also thinking in terms of possible methods of mitigating microbial corrosion?

DR. HORN: You know, I think that was sort of -- you know, because anything would have to be a kind of engineered approach, and I think everybody is very hesitant to –- you know, for example, I think somebody really early on suggested, well, why don't you add a micro side, and I think over a 10,000 year period that everybody is fairly convinced that just is not a practical approach.

So what we are doing is trying to rely on the materials to resist corrosion, rather than trying to get rid of the bacteria.

DR. GARRICK: Okay. Thank you.

CHAIRMAN HORNBERGER: Joanna, I am still

-- I am interested in how the results actually get scaled to the repository, and again in this sense, I asked you the question about the source of energy to run this system.

And you replied, well, it could be on a chemoanotropic base.

DR. HORN: Right.

CHAIRMAN HORNBERGER: Or it had to come in with the water. In either case it strikes me that the 10 to the 4th and 10 to the 5th bacteria per gram of rock is not a big thick biofilm.

DR. HORN: Right.

CHAIRMAN HORNBERGER: And I can't see that you are going to bring an energy source in with the waste package.

DR. HORN: I guess the thing that concerns me is that when you do add that ground water, even without a carbon source, you see up to 10 to the 8th bacteria, and that is actually per ml.

That is actually the platonic bacteria that are floating around in the aqueous phase, and bacteria like to stick to things. So it is at least that many, and there is probably more stuck to the rock.

DR. HORNBERGER: Then why do you only

measure 10 to the 4^{th} and 10 to the 5^{th} in the rock?

DR. HORN: Because you don't have water there now, okay? So right now there is 10 to the 4^{th} to 10 to the 5^{th}, but they are looking at perturbing the system and we are going to drive the water away presumably and then it is going to come back.

And I think the infiltration rates are going to be what determines the microbial growth.

CHAIRMAN HORNBERGER: So basically you are looking at this as a potential problem in the superfluvial, where the infiltration rates are higher?

DR. HORN: Precisely.

MR. LEVENSON: One of the things that I have been asking about I can't seem to get an answer, as to why with the present design the inner-container is stainless steel instead of just iron or carbon steel, from just the standpoint of microbial corrosion, or microbial enhanced corrosion.

Is there any advantage to stainless steel, as opposed to ordinary steel?

DR. HORN: Well, right now we are really not taking any credit for the inner-package. It is just as a structural support for the outer package.

MR. LEVENSON: I know that they are not taking any credit, but as a taxpayer, I am paying for it.

DR. HORN: Yes. Well, I think I am going to call on Dan for this because he has been around the carbon steel days, and has more of a justification for the switch.

MR. MCCRITE: Just arguing from general corrosion to stainless steel, the general corrosion rate will be under almost any circumstance will be less than carbon steel.

So one of the reasons for picking stainless steel for the inner-barrier than carbon steel was that if and when the outer barrier is breached, if it were stainless steel, it would corrode still much the same way as the Alloy-22 did by some localized mechanism.

If it is carbon steel, it will corrode much more vigorously, and probably with some volumetric change, and so in which case the whole package would stand to rupture open, and more so if it were a more corrosion resistant material inside.

So again our concept of the corroded waste package is that we would never have lots and lots of area exposed, and that it would be just crack by crack and tit for tit. It would be a very small, small amount of actual area that was corroded through and where the water could penetrate through, rather than a very large area.

So we thought that the stainless steel inside would help in that argument.

MR. LEVENSON: But the argument that you are not making, since you are taking zero credit for it.

MR. MCCRITE: That's right from the containment point of view, but thinking that other people in their analyses may want to consider the pathways of water in and the pathways of radio nuclides out.

And that this is not our argument in the containment group, but as to others as being a total barrier system.

CHAIRMAN HORNBERGER: Questions from the staff? Mike.

MR. LEE: Mike Lee, ACNW staff. The Yucca Mountain rock, is that just the Calico Hills crushed tuff?

DR. HORN: Actually, I think it is Propone Springs tuff. Actually, we have isolated it from where we excavated it from Alco-5, which is in the same horizon as the repository.

NR. LEE: Okay. So it is a pretty fresh

sample then?

DR. HORN: Yes, and I just want to mention that in these studies we really have not made a distinction between organisms that are introduced as a result of construction activities, and those that are extant. So we really have not separated those out, because I don't really think it makes any difference to the project in the end.

I mean, they are going to have to deal with the whole thing. So we have tried to get it, and we have done both getting it off the surface of the walls, and inside as well.

MR. LEE: And my other question is that there is going to be a lot carbon steel possibly in the repository as a result of roof enforcement and things like that, and rock holes, and stuff.

Is there any plan on looking at the effects of microbial induced corrosion there?

DR. HORN: Well, we have done some of those studies and we did some lineal polarization and this was primarily at the time when carbon steel was the outer layer of the corrosion at the waste package.

But knowing that, there are other elements of the engineer barrier system that are close to steel and that's why we characterized the corrosion products and looked at the overall rates of corrosion.

But more recently we have frankly been focusing in more on the Alloy 22 and titanium, because it is just more of a priority.

CHAIRMAN HORNBERGER: Andy.

DR. CAMPBELL: Getting to the water issue, how much water do you need? We took a tour of Yucca Mountain yesterday and went into the cross-drift, and saw and heard discussion about mold spores. In fact, we all had to sign our life away saying that we would not hold DOE responsible.

Mold grew rapidly in that environment once it was closed up. Now, there is no liquid water there that is dripping as far as you guys and as far as DOE knows. But there is a heck of a lot of moisture there in terms of humidity and condensation.

And even without a punctured drip shield, as the waste packages cool, do you believe that there would be sufficient moisture on the surface of the waste package that these organisms could grow?

DR. HORN: Yes, I am well aware of the cross-drift issue, because when it first came up it was primarily the S&H issue, and they brought us in to do this survey of fungi. They were growing on just about everything organic down there.

And so if you look at the literature, fungi are a little more justification resistant than bacteria, but it is on the order of 95 percent Rh. Now, that doesn't include -- you know, there is some discussion that as salt brines actually build up on the package, or for that matter on the drip shield, that the deliquescence point or that point of relative humidity, where the salt actually absorb water, and produce a water film, can actually be at a lower relative humidity than that turnaround point for general microbial buildup.

So I think there are those two issues. Yes, we are saying 90 or 95 percent Rh, but that doesn't include the deliquescence point of the salt. Now, I just want to point out that if they grow in these mines, they have got to be very salt resistant organisms.

And those do exist, and I live in San Francisco, in the Bay Area, and if you have ever flown into South Bay, you will see these big salt ponds that are all red, and the reason that they are red is that there are organisms called halo bacteria that are very salt resistant, and that have these red pigments that grow in there.

So, so far we have not seen it in halo

files, or what we call halophytic or salt loving bacteria in the repository, or we have not seen them in the test kits either. So that is good news.

So how much water? Well, if it is free of relative humidity, then probably we are talking 90 to 95 percent, and all you need is a film. You don't need it to be dripping.

But then you might start at relative humidities if you have halo tolerant bacteria and you get this deliquescence on the packages or other surfaces.

MR. LEE: One other comment. In another life I actually worked on hydrothermal vent systems, and marine sediments, and in answer to Ray's question, you generally see some sort of divergence of the methane producers, versus the sulfide producers, versus the sulfate producers, and sulfide oxidizers, excuse me.

And you see a stratification in sediments, but frankly you see a lot of cross-over and you see mixtures of bacteria that in theory should not be growing together and they are, and the usual explanation was that you have micro-environments that favor either more reducing or a more oxidating environment.

And the other thing is that hydrothermal vent systems have these wonderful communities of life moving around and they are all living on essentially the bugs that oxidize sulfite, as a completely chemorodicthrophic system.

And so once you get one growing, pretty soon you colonize it with all kinds of other things, and the last thing is to remember that the reason we have oxygen in the atmosphere is because of bugs. So no matter where they are, in the earth, or even deep into the earth, one finds bacteria, and they are living off of some sort of energy source.

CHAIRMAN HORNBERGER: Don't forget there has to be an energy source, and there is a pretty darn good energy source at those vents. Any other questions nor comments from anyone?

MR. SHETTEL: Don Shettel for the State of Nevada. Are you planning to look at any other water compositions besides J-13?

DR. HORN: Well, the problem is that you look at more materials and more water -- well, we are looking at high reactions and other pHs in the context of what we saw in corrosion tanks.

MR. SHETTEL: Well, does that mean like 10 times --

DR. HORN: Actually, the more concentrated, it is a thousand times. We are attempting to expand the matrix somewhat, but it is just difficult because a lot of these are long term tests, and they take a lot of maintenance, and how to gauge that is difficult to accomplish.

MR. SHETTEL: Yes, but port water has higher sulfate and nitrate, which might be important.

DR. HORN: Well, already we know that the ground water has enough sulfate and nitrate. You almost can't have too much sulfate and nitrate for bacteria, because that is what we call macronutrient.

I mean, it is in all your proteins, and your DNA and all the membrane proteins. So you need a lot of phosphate and sulfate, nitrate, or nitrogen, and sulfur, as well as a carbon source. And those are the four things that you need a lot of.

So to increase it 10-fold wouldn't be a bad thing. It wouldn't prevent microbial growth. We are more concerned with nitrate concentrations being depleted by bacterial growth because it turns out that nitrate kind of combats chloride. Chloride generates corrosion, and nitrate sort of emolliates that effect. So the nitrate and chloride concentrations are important, and those ratios are important and is something that we are interested in looking at.

MR. SHETTEL: And my next question is that I know that you are going to try different temperatures, which is good, but when the coupons are submerged below the solution though, that is okay for anaerobic bacteria, but with the aerobic ones, you should be trying perhaps to drip the water on the coupon.

DR. HORN: We have thought about doing that. Actually, in the tanks, they are very vigorously mixed and so it is an area of environment, and it is not a closed system. It is generally closed, but it's not like it is sealed. And then these things are being continuously mixed.

MR. SHETTEL: And that would mimic a thin film, and you might find on the canister?

DR. HORN: Right. And when we sample the tanks, we actually swipe the surfaces, too, to see if we can expect more to be attached to surfaces.

CHAIRMAN HORNBERGER: I don't want to interrupt, but I don't want to carry on too much into deeply exactly what is measured, and what the plans are, because a lot of this can be done off the record. Is there another question?

MR. TYNAN: Mark Tynan, from DOE. I was

going to try to lead you to the final question. If you look at the species that you have identified from the rocks at Yucca Mountain, how do they differ form the ones that I find in my aquarium at home?

DR. HORN: Well, your aquarium is a little bit different environment. But in your garden, I would say they are a lot closer, although generally there is a lot more organic material in your garden.

MR. TYNAN: How about on the surface area at Yucca Mountain?

DR. HORN: You know, we haven't actually looked at that, and that is one of the things that I have been wanting to look at, particularly in like the playus (phonetic), these dried up salty lakes and so forth in that area, because that may be a good mimicking environment for these surface grinds that they are expecting may develop on the surface of the packages. But great question. I would love to do the experiment.

MR. TYNAN: From what you have looked at, your factor of two on C22, is that incorporated in the TSPA SR?

DR. HORN: Yes, it is.

MR. TYNAN: And is it included in SSPA and the FEIS calculations?

DR. HORN: Yes.

MR. TYNAN: And so you are adding some new things in the future that will be available throughout that will be available for LA that you indicated --

DR. HORN: Absolutely. And I know that a lot of this data is in the data bank, and we very shortly are going to be putting a lot into it.

MR. TYNAN: And then my last question is that I am leading up to is does your study indicate that long duration ventilation would be bad for the repository because of introduction of organisms that aren't there?

DR. HORN: Well, it is kind of a double-edged thing, because you are going to be introducing organisms, but you are also going to be drying things out. And I think probably the dryout factor overrides the introduction factor, because if you dry everything out, nothing is going to grow anyway.

So I think during the ventilation period it is a good thing in terms of corrosion, because it will eliminate water.

MR. TYNAN: Okay. Thank you.

MR. LEVENSON: I have one other question. You showed pictures of several different types of equipment, but just to get a feel for the scope of the program, how many specimens total do you think there is, including your long term programs?

DR. HORN: I think a couple of hundred.

MR. LEVENSON: A couple of hundred?

DR. HORN: Yes.

MR. LEVENSON: Some of the tanks have more than a hundred.

DR. HORN: Yes, but we go like into depth on each coupon.

MR. LEVENSON: No, I mean the total number of coupons you have in the program.

DR. HORN: You mean in the entire program?

MR. LEVENSON: Yes.

DR. HORN: Go ahead, Dan.

MR. MCCRITE: We have more than 20,000.

CHAIRMAN HORNBERGER: Thanks very much, Joanne.

DR. HORN: Thank you all for your attention. It has been a long day and I really appreciate it. Thank you.

CHAIRMAN HORNBERGER: I think because we had a break earlier, we are just going to continue on with our agenda. Our agenda now is open, and basically we are open for questions and comments on anything that has been heard today and actually not even restricted to anything that has been heard today. We are open to hear any questions or comments that people may have.

(No response.)

CHAIRMAN HORNBERGER: If not, very good, and thank you all for attending. We are adjourned.

(Whereupon, at 5:13 p.m., the meeting was adjourned, to reconvene at 8:30 a.m., on Thursday, September 26, 2002.)